Igloo: Mobile Learning System to Facilitate and support Learners and Educators

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Abstract— The proliferation of mobile devices as well as the convergence of mobile communications and handheld devices offers the opportunity to design technology that will assist individuals and groups to learn anytime, anywhere. Therefore, mobile technologies are increasingly used to facilitate learning process and the use of these technologies creates new opportunities and challenges. However, designing, implementing and evaluating educational technology in mobile learning is largely unchartered territory. This paper describes the design, implementation and evaluation a mobile learning technology, namely IGLOO for mobile devices. It is intended to support educators as well as students in a learning environment. A working prototype system is discussed and evaluated.

Keywords—Mobile learning, MobilED, design, development, research, application, Activity Theory.

I. INTRODUCTION

Mobile learning offers an enhanced environment in education. Initial research in the MobilED initiative have documented the potential of and the lessons learnt in employing mobile technology in secondary schools in South Africa [1], [4], [6], [16], [18], [19], [28]. MobiLED (Mobile Education) started as an international collaborative project between the South African based Meraka Institute (CSIR), University of Pretoria, Tshwane University of Technology as well as international partners, the Media Lab of University of Art and Design Helsinki (Finland), Escola do Futuro Universidad de São Paulo (Brazil) and the WikiMedia Foundation (United States) in 2006. The aims have been to integrate mobile technology and services into the areas of teaching and learning and thus promote meaningful interactions with information. We have posited that in the absence of desktop computers and ubiquitous internet access, mobile phones are able to provide an alternative access to the information age, supporting education and educators to prepare learners for full participation in the knowledge society and the acquisition of 21st century skills. [6]. It has been the aim of the initiative to build and test models and scenarios that are founded on practice and based on pedagogical principals.

Although educators have been very positive about using mobile technology at the schools where the initial pilots were held, they often expressed their frustration at the lack of applications that would support the use of mobile phones in class beyond the built in facilities available to learners. This lack of available software on the one hand and near ubiquitous penetration on the other, presented us with a unique opportunity. Applying design principals derived from a conceptual framework based on the activity theory, we designed, implemented and evaluated an iteration of mobile technology that would support activities and practices of educators [5] using mobile technology not reliant on GPRS connectivity.

Information **G**athering and **L**esson T**oo**l (IGLOO) is fully described in section 3. Section 2 of this paper outlines the general requirements for Igloo as they were identified. The following section motivates learning with mobile devices. Then we present IGLOO by describing its design and development and its implementation on mobile phones as well as its design requirements. The section "Evaluation" reports the studied carried out with the learners of a high school while using the system and its theoretical background. The paper concludes by presenting our research contributions to mobile learning development.

II. OBJECTIVES

The aim of this development was to supply educators with an application that would run on mobile phones independent of GPRS connectivity or functionality and could be used to facilitate pedagogical practices in formal and informal learning scenarios. As mobile technology has the ability to extend the borders of formal education beyond the physical brick buildings characteristic of formal education, it is desirable to extend pedagogical practices to where learning occurs. The development of the **I**nformation **G**athering and **L**esson T**oo**l (IGLOO) is based on design principles derived from a conceptual framework that evolved from the incorporation of pedagogical and technical aspects that designing for mobile learning involved [5].

Technology is never valued free, as programmers, practitioners and researchers all imbed value into the design,

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implementation and evaluation. The tenets that underpin the MobiLED initiative in general and this application in specific are founded in the social constructivist view of learning. In a broad sense the social constructivist paradigm views the context in which the learning occurs as fundamental to learning itself. Technology is then viewed as a tool that supports and enhances communication, interaction, collaboration and the construction of knowledge within a context.

As the MobiLED initiative is grounded in the pedagogical practices of educators, the design focused on the actions and activities of educators as they strive to teach in order for students to learn [2], rather than design towards a model of what these practices ought to be. These existing practices and requirements were taken as design criteria with technology viewed, not as an agent of change, but rather as a tool to support practice. Thus the activities of an extended contextual classroom and the views of the social constructivist learning paradigm formed the heuristics that governed the design.

III. Methodology

The Activity Theory is referred to as a "commonly accepted name for a line of theorizing and research initiated by the founder of the cultural-historic school of Russian psychology" by [9]. [10] state that the underlying philosophy of the theory is to explain human activity and behaviour. The analysis of human actions and interactions is consequently based on their activities. These activities cannot be understood or studied outside the context in which they take place [8]. An examination of these activities lead to an analytical reflection of the activities, the participants, the outcomes that want to be achieved, the rules that govern the activities and participants in the activities and the broad community in which these activities occur [13]. These components can be reflected in Engeström's extended model of the activity theory [8].

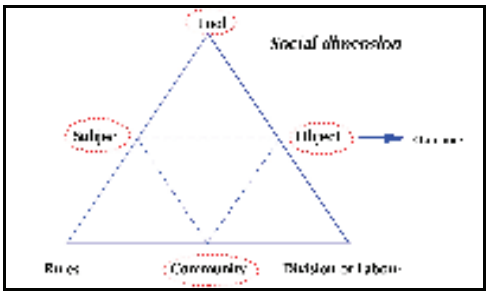

Figure 1: Extended Activity System (Engeström, 1987)

In figure 1 above, the subject represents the participants involved in activity; the object is the outcome or goal that the activity is seeking to achieve. This provides the intentional motivation for the activity. The community is the social space in which the activity takes place, the objectives are to be achieved and the participants have to navigate. The tool is that which mediates the activity of the subject as he acts in order to achieve the goal [19]. These tools can be either physical tools such as computers, mobile phones, hammers or other tangible objects, or they can be mental tools, such as language or models. When we view the use of physical tool to mediate the actions and activities, the use of complex tools such as computers differ from the use of simple tools such as a hammer or a knife. Complex technology tools often have different functionalities and each of these functionalities can open up new opportunities and activities for the user. The user in turn needs to apply a new set of navigation rules to use the functionality in the activity. The computer and mobile phone add new virtual communities to the context. These virtual communities have their own culture, rules adding complexity to the context of the user. These added complexities that present itself can be depicted as a technology dimension that the user has to navigate in addition to the social dimension. These dimensions can be represented as in figure 2 below.

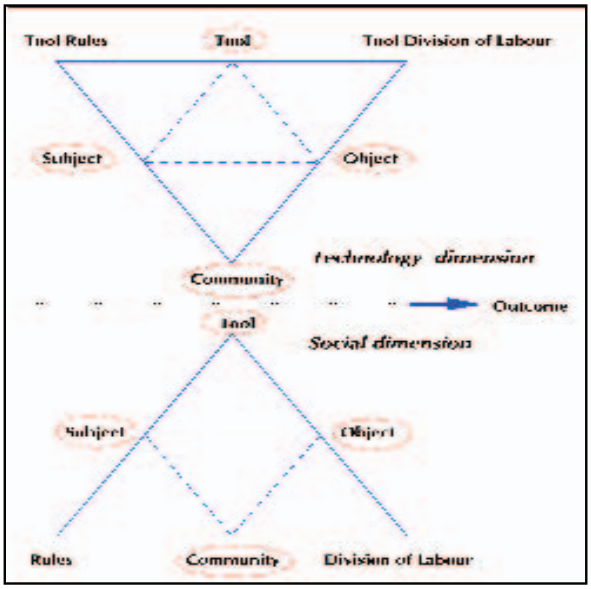

Figure 2: Technology and Social Dimensions Extended

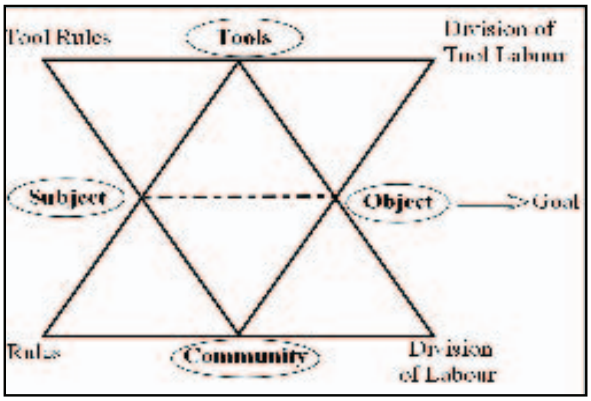

Figure 3: Framework with overlapping dimensions to form the conceptual framework

In figure 2 above the top sketch is a depiction of the technology tool dimension and the bottom sketch represents the social dimension. Ignoring the importance of the social implications of a mobile learning environment has resulted in "the almost zero adaption of technology" [10]. The tool dimension cannot be ignored either as the potential of the

environment needs to be supported by stable technology. From literature, the rationale for a dual identity of the research in mobile learning is very apparent. It leads to the conclusion that in practice there needs to be a dialectic nature to the dimensions as the pedagogical underpinnings and the technology that mediate it are interdependent. Focusing on only one dimension results in a breakdown of the activity as a pedagogically sound mobile intervention cannot take place without stable technology to mediate it and in the same way technology without sound pedagogical practice is educationally useless. The challenge is in a sound development where both contributions are acknowledged. In the Figure 2 & 3 above, the tool rules represent the interactions that the user will utilize to access a specific functionality of the technology tool. An example of this would be the predictive text on a mobile phone or the keystrokes that have to be used on a phone keyboard to text a sms, sending a picture via MMS or activating and side-loading a video through Bluetooth. Opening a text message, storing it and moving the message to other folders are additional functionalities under the tool division of labour that would each necessitate specific interaction from the user by the technology. Each of these functionalities employs a set of rules that the user has to master.

The community represents the virtual community that the user enters through the use of technology or the platform that supports the interaction. This is imprinted upon the real world community as the interaction is still contextualized in the real world.

IV. Design and Development

The design and development of the application evolved from the conceptual framework briefly discussed in Figure 3. However, the technological dimension of the conceptual framework can be considered as a guide to the engineering endeavour while the pedagogical dimension frames and contextualizes the application. The specifications of the application are derived from the activity that the user wants to support with the tool. Considering the three mediated relationships illustrated and discussed in the subsections below which is mediated and supported by the figure 4 below:

A. The Subject Object relationship mediated by the tool (1)

The design implications of this relationship are to determine the tool-activity. The more aligned the tool-activity is with the activity of the user, the greater the usefulness of the tool will be. The igloo application was aimed at delivering a set of multimedia questions consisting of open questions as well as multiple choice questions to a user's mobile phone to support the formative evaluation and information elicitation practices of educators as well as researchers.

This application, and by implication, the questions, had to be accessed by the learners or participants at anytime, anyplace, giving the assessment mobility. This would allow the educator to assess learners in the real world directly after or while they were busy with situated activities. Learners could, for example be assessed on field trips, asked describe an artwork in a museum or give coordinate of structures. The question could also be used to focus the attention of learners on the detail of a scenario.

To support this mobility of assessment, the educator thus has to be able to "write" an application that will appear on the learner's own personal mobile phone. This physical mobility of the learner or participant is therefore incorporated by either allowing the user to submit the answers by Text message or by Bluetooth. The text messages are sent to the educator's phone from anywhere where there is cell phone coverage. However, in order for the Bluetooth capabilities to work it is necessary that the educator be in a close proximity of the learners or participants.

B. The object-tool relationship mediated by the tool division of labour or available functionalities (2)

The functionalities that would have to be incorporated to sustain and align the tool-activity with the motivated activity of the subject were gained through consideration of the subject-object relationship. The application would be required to:

- Allow mobility of the user in physical space. The location as incidental backdrop or relevant to learning would be incorporated by enabling the user to access the questionnaire and submit the answers only dependant on the accessibility of mobile technology.
- Allow mobility of technology. The application, and by implication the questionnaire, would be accessible from any mobile technology supporting Java.
- Support mobility in social space. The application, by nature of its physical mobility, sustains multiple contextualized social spaces in terms of formal or informal collaborative groups.
- Support learning as dispersed in time by enabling the learner to submit and/resubmit electronically. This time is logged on the educator's phone. If the learner submits work multiple times, only the last copy is considered when results are calculated but the other copies are available to the educator. This potentially extends the formal learning space to informal space [24].

C. The tool-subject relationship mediated by the tool rules (3)

This relationship focuses on the user interface and the norm and rules that govern the user's interaction with the technology. Each of the functionalities would necessitate that the user employ separate navigational protocol. The application, and by implication the technology, will become useful to the subject when they are able to confidently and effectively navigate the interface to utilize all the functionalities.

Adding or different interactions makes it necessary for the user to acquire a proficiency in a new set of actions [15]. In essence the design of the interface of the application was deliberately planned to reflect actions that users would already be familiar with in everyday use of their mobile phones.

The application consists of a "back-end" administration system and a mobile application that runs on a phone which is able to receive and respond to the end users. The administration application allows the educators to setup a multimedia questionnaire/test/quiz which can include photo and/or sound files. This application supports open ended questions as well as multiple choice questions (please, refer to Figure 5 below). It runs on a standard PC running Microsoft Windows. The mobile application was packaged with the questionnaire file for distribution.

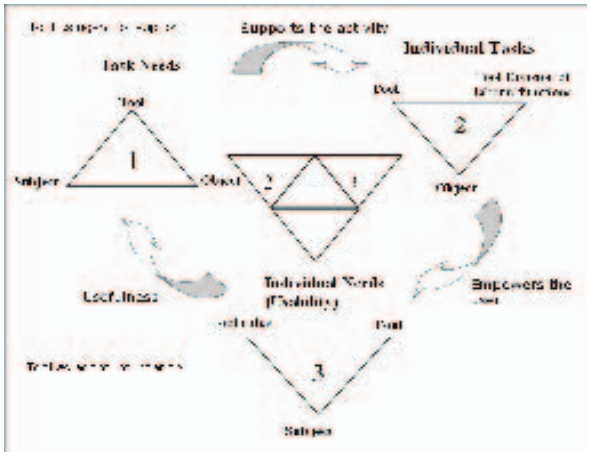

Figure 4. Design flow

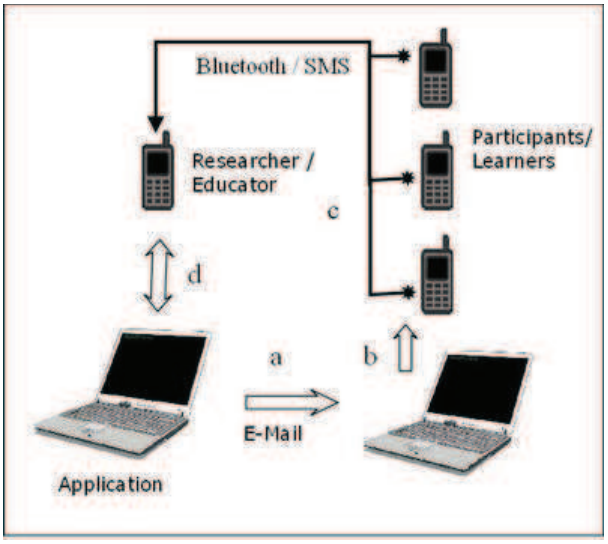

Figure 5. Application flow

V. EVALUATION

The results from the activity theory have been applied in implementing a system to support both learners and educators as presented in the design and development section. However, [14] argued that designers or researcher may not know how useful their system is until an evaluation of the system has been carried out. Hence, we evaluated our system.

Our evaluation focused on determining the tasks the users achieved in using the system, rather than evaluating the system performance [27]. Also we were not so interested in how efficient the users were in using the system but rather how well the system supports the goal of the user [21]. Therefore, a prototype application that was developed was presented for the purpose of this evaluation. This is because we were not interested in knowing whether a user knows how the system was encapsulated but rather how well the system can help the user achieve the task for which it was designed [6].

To this end, the prototype application was evaluated with high school students and their educator as our subjects or participants. We wanted the tasks that would be carried out by subjects to be simple enough so that users will be able to evaluate the system successfully [6], [21].

A. Subject in the Evaluation

During the evaluation of a system, it is imperative to choose/select subjects from a population that will use such a system. [22]. However, [21] argued that when conducting evaluation, it is important to recruit subjects who represent the sample population for which the system is targeted e.g. users with some range of expertise in the context of the study. In this study, the subjects were high school students and their educator(s).

Also, it will take many more than five users to successfully evaluate a system [25]. Also it would take more than more than five or seven subjects per cell for the evaluation of a system or design where a cell represents a class of subjects who represents the users [22]. Therefore, we evaluated our design with thirty eight (38) subjects, thirty seven (37) of which were high school students from Pretoria in South Africa and one (1) of them being the educator.

B. Task in the Evaluation

The following three tasks were identified in order to evaluate the system that was developed to support learners and educator(s).

Task 1: To use the system to answer the questions as were presented to them by their educator on their mobile phones. The questions could be downloaded via a wap site.

Task 2: To submit the answers via sms to the educator. We were however, responsible for the cost of sending the sms.

Task 3: To fill and submit a questionnaire evaluating the user's experience while they were using the system.

A pilot study was also conducted with the potential users who would not be involved in the main evaluation study in order to determine the viability of the experimental procedure [22]. This also helped us to define the criteria that would constitute successful completion of the task.

C. Evaluation Environment

In order to guarantee comfort and provide a familiar environment, the evaluation was conducted outside the school environment of both the learners and educator. The evaluation was conducted at Maropeng in the north-west of Gauteng Province. Maropeng is one of the seven (7) world heritage sites in South Africa and it also serves as an excursion site to South African High school students. The users' privacy and their confidentiality were maintained throughout the process of the evaluation. This, we did in order to consider the ethical issues that are related to user evaluation as pointed out by [22].

D. Evaluation Procedure

On arrival, the agreement/consent form was given to subjects to fill, sign and submit,. After this, subjects were introduced to the system as well as the evaluation that was to be performed and instruction on how this would be done was given. The purpose of this was to make sure that all subjects were given the same information and instruction.

The subjects were asked to work alone with a mobile phone of any make and model. Each subject that participated in the evaluation study did so seperately.

Each subject was then asked to complete the three tasks and give verbal feedback during task completion (think aloud) [14], [22]. They were given up to 30 minutes for the first task, 15 minutes for the second task and 10 minutes for the third task. If they did not finish a task within the allotted time they were ask to stop. When all the tasks were completed, the subjects were given a post-test questionnaire which consists of items derived from the QUIS user satisfaction questionnaire [7] to fill and returned before leaving the evaluation environment. When the questionnaire was completed, a debriefing session and an unstructured interview were held in which the subjects were asked for their opinion [22].

We wanted subjects to complete these tasks to investigate and assess the suitability of the application as realistically as possible based on the following two assessments:

- How well the application was designed.
- How easy the system was, in terms of time to complete tasks by subjects and error rates during task completion.

In summary, there were four different sections during each evaluation and all these took up to 1 hour on the average. These sessions were:

- Introduction of the system and the experiment to perform
- Tutorial about using the system
- Carrying out the tasks using the system
- Questionnaire administration, debriefing session and unstructured interview.

E. Results and discussion

Responsiveness is the most important factor in determining users' satisfaction with a system [22]. All the users found the system satisfying. This was further confirmed in the unstructured interviews conducted after the evaluation.

The result of our observation coupled with the users response from the questionnaire shows that 78% of the subjects find it simple to quickly learn how to operate the system while 72% of the subjects got started with the system quickly. It was observed that only 1% of the users found it a little difficult to get the scope of the system at the beginning. The result from the users' response showed that the time to learn and operate the system was very quick. Also, our result showed that 78% of the subjects agreed that the system was very fast; it took less than five (5) seconds for the application to load on a mobile phone.

Our result showed that 76% of the subjects agreed that the system was reliable because during system usage, no error was encountered. Some the errors have been pointed out and dealt with, during the pilot study. However, 85% of the subjects agreed that the ease of operating the system depends on the level of experience that a subject has in using mobile phones to operate a customized mobile phone application.

VI. Findings and Results

Understanding how and where to improve the environment for mobile learning, requires some investigations in order to learn about daily learning activities in the educational environment [25]. In order to achieve this, the researcher/designer has to conduct an observation of users while using a system. This can be achieved through direct observation [14], [22]

To this end, we conducted a direct observation of Thirty seven high school learners while they use the system to achieve learning activities using direct observation (DO).

The following data and results were collected and obtained from our DO method: 89% felt that Igloo supports the way in which they do their work. In the follow-up interview [14], [22]; it was clear that learners experience a rich application which really defined how they would like to do their work in the classroom. Also we found out that learners expect mobile application to run correctly on all J2ME-enabled software and hardware (e.g. J2ME-Enabled mobile devices). But this was not always the case [17].

VII. Conclusion

Several authors have agreed that the slow progress of theories and methodologies about the computing technologies is as a result of lack of empirical studies [12]. Mobile devices are carried by many people everywhere and at all times. However, insights into their experience with the devices they are carrying are captured better in a field study than in a controlled environment. In order to be able to exploit the positive characteristics of mobile technologies for learning, new teaching/learning must be defined [3].

One contribution of this paper is the methodologically sound approach that was adopted in designing, implementing and evaluating our system. Another contribution is the novel m-learning technique that was adopted in implementing the system (Igloo) which is inspired by the excursion-activities that was originally proposed by the educator.

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