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CROSS-CULTURAL DESIGN OF MOBILE MATHEMATICS LEARNING SERVICE FOR SOUTH AFRICAN SCHOOLS

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ABSTRACT

In the era of mobile devices and services, researchers in the educational domain have been interested in how to support learning with mobile technology in both local and global contexts. Recent human-computer interaction (HCI) research in the educational domain has particularly focused on how to develop mobile learning services and how to evaluate the learning outcomes. However, learning occurs in a local cultural context and the impact of culturally sensitive issues of the design of mobile learning needs more attention. We studied mobile mathematics learning -service in a longitudinal research with over 30 South African schools during three years. Our aim was to understand culturally dependent issues which need to be taken into consideration in the design of mobile learning services. We found subjective and objective culturally dependent issues in the content, context, infrastructure and technology of mobile learning and therefore, subjects to cross-cultural research. In conclusion, we argue that localization enhances the user experience and therefore support learning.

KEYWORDS

Cross-Cultural Design. Mobile Learning. Cultural Context. Subjective and Objective Culture.

1. INTRODUCTION

Due to globalization and pervasive nature of mobile services, an increasing number of diverse users are able to take mobile learning services into use. Demand for fast development of mobile learning services poses challenges for designers. Sharples et al. (2010) stated that “children are developing new skills and literacies enabled by mobile devices, such as SMS texting, moblogging” and the m-learning development should be aware of the development.

Motiwalla (2007) developed a m-learning framework for push and pull mechanism to be able to evaluate the personalized and collaborative content in m-learning applications. Moreover, Sharples (2009) outline methods for m-learning and present a socio-cognitive engineering approach (Sharples et al., 2002) to support design. Thus, recent research indicates how to support and evaluate personalized and collaborative m-learning. However, is this phenomenon similar everywhere from a
global perspective?

The era of mobile devices and services has opened up a whole new way to learn to create possibilities for making information accessible for everyone and everywhere (Kukulska-Hulme et al., 2011). Nevertheless, the main focus of design and implementation of mobile learning services has been focusing on learners in western countries. In the study of cross-cultural patterns in mobile phone use by Baron and Segerstad (2010) it was pointed out that although contemporary mobile phone technology is becoming increasingly similar around the world, the cultural differences between countries may also shape mobile phone practices. Thus, to be able to understand how to design the m-learning services that fit the needs of different local learning contexts, more knowledge what are the typical practices for different cultures, is essential. The understanding of cross-cultural issues, e.g. what is valuable for the users (Cockton, 2008), in the design of technology supports the development of good user experience of mobile learning services in different local contexts. This is a vital issue when integrating mobile learning into the everyday processes of an ordinary school day in different countries with different cultural backgrounds. Research of cross-cultural issues in the field of human-computer interaction (HCI) has been focusing, for instance, on the design of web-pages for different cultures. However, there is not yet much research available of how mobile learning is affected by the cultural context and local learning cultures and how this should be considered in the design of m-learning technology.

In this paper, we present the results of a longitudinal study of culturally dependent issues in mobile learning service for mathematics. The aim of our study was to identify culturally sensitive areas in m-learning services. The results of our study will bring insight about culturally sensitive areas in mobile mathematics learning service which can help practitioners in localization of other similar m-learning services.

Our research focuses on a large scale and longitudinal study of learning mathematics by mobile phones. The Nokia Mobile Mathematics -project has been carried out in amongst secondary school teachers and pupils in urban and rural areas in South Africa. The project started in 2009 and is on-going reaching now already some 50 000 pupils and 700 teachers and is also aiming at other African countries such as Senegal and Tanzania. Recent research by Masita-Mwangi et al. (2012) has proposed m-learning with mobile phones as a viable and logical channel of delivering education for African youth.

Our main research question was: What cultural issues need to be considered in the design of mobile mathematics learning technology? The sub question in our longitudinal study was: What is the cultural context of mobile mathematics learning in South Africa? This paper brings insight into cross-cultural design practices for both academics and practitioners. For practitioners, our results describe knowledge of understanding practical cultural sensitive issues that have an impact on m-learning activities. For academia, the longitudinal results of cross-cultural research, resulting in both subjective and objective aspects categorized into the content, context, infrastructure and technology of mobile learning.

2. CROSS-CULTURAL DESIGN

Cross-cultural design is designing technology for different cultures, languages, and economic standings ensuring usability and user experience across cultural boundaries (e.g. Aykin, 2005). The demand and opportunity for cross-cultural design has rapidly arisen due to globalization: As companies are expanding their customer basis across national and cultural boundaries, cross-cultural issues have practically landed on designers' desktops and made them think about the cultural elements in design (e.g. Sun, 2012; Aykin, 2005). Whether it is about designing mobile phone applications, web-pages, tractors, cranes, lifts or washing machines, designers need to think about the end-users all around the world in different cultural contexts. Consequently, when designing for global and local users there are an unlimited number of ways to get it wrong (Chavan et al., 2009).

Culture is a complex concept and there is no simple explanation for it. According to Keesing and Strathern (1998) most anthropologists agree that culture is a learned behaviour consisting of thoughts, feelings and actions and is transferred in social interaction. Some anthropologists would like to limit the concept of culture to national and ethnic cultures, but most anthropologists seem to agree that social interaction is the most important prerequisite to produce and maintain a culture (Keesing & Strathern, 1998).

One way of looking at the concept of culture and bring it in to more practical level for a designer is to try model it somehow: of what it consists of and in what levels. Many researchers in the field of anthropology have studied objects, the patterns of behavior and thinking that differentiate one culture from another. For instance, Stewart and Bennett (1991) and Hofstede (2001) have compiled these into cultural meta-models.

Although technology researchers and practitioners have long been aware of the challenges of the global markets, there are still many unsolved problems concerning the extent to which culture may affect the product design and how to evaluate and analyze it (e.g. Smith et al., 2005; Schumacher, 2010). The influence of culture on user research has received much attention without much in the way of theory to support it (Snitker, 2010).

Two essential issues in cross-cultural design are identified as objective and subjective (e.g. Aykin, 2005; Smith et. al, 2005): There are objective issues, such as the language and format conventions of time of day, dates and number, and text directionality in writing systems. In addition, there are subjective issues such as value systems, rituals, behavioural and intellectual systems of one or more cultural groupings of users. All these aspects can affect the way how people in different cultures use and accept technology. These "deeper" levels of culture are often hard to study without user-centered research. In anthropology, an interpretive approach to the symbolic system of culture includes a long period of intimate study and participation in the everyday activities of the cultural members. Therefore, the analysis is context sensitive and interpretive and should focus on the "natives' point of view" (Czarniawska-Joerges, 1992; Iivari, 2004; Keesing & Stratherm, 1998; Smircich, 1983). This suggests that longitudinal user-research could bring knowledge of those hard to examine culture sensitive issues for design.

Oyugi et al. (2008) categorized two areas in the design of technology that can be affected by culture: In relation to the actual product of development, cultural differences in signs, meanings, actions, conventions, norms or values raise challenging issues in the design of usable localized artifacts (Oyugi et. al, 2008). This means the actual artifact that is being created. In relation to the process of development, cultural differences potentially affect the manner in which users are able to participate in design and act as subjects in evaluation studies (Oyugi et. al, 2008). This means in practice that some user-centered research methods might work better in some cultures than in others. For example, usability evaluation methods developed in Western world can be less effective with African or Indian users than with users from UK (Oyugi et. al, 2008).

The user-centered design approach supports the cross-cultural product development process with user-centered activities (e.g. Aykin, 2005) identifying the need for internationalization and localization. Cross-cultural user research on-site or remotely will help to understand what and how has to be internationalized and localized.

3. MOBILE LEARNING AND SOUTH AFRICAN LEARNING CONTEXT

Learning with mobile devices is a global aim and phenomena, see e.g. UNESCO's Education for All principle and Mobile Learning Technology Concept Development. Not only in the developed countries but also in the developing countries the spread of mobile technology has been rapid during the past ten years. According to Sharples et al. (2010), "new skills and literacies are enabled by mobile devices, such as SMS texting, moblogging (writing diaries and weblogs on mobile devices) and mobile video creation. A new generation of location-aware mobile phones will offer further possibilities, of education services and educational media matched to the pupil's context and interests". Due to the fact that mobile learning has become a global phenomenon and existing design and evaluation principles are developed mainly for the users in western developed countries, these principles should be critically analyzed.

Several studies have been made about how to design, develop and evaluate mobile learning (e.g. Motiwalla, 2007; Sharples, 2009; Chu et al., 2010). However, only a few, if any studies focus on the longitudinal evaluation of the development process of a mobile learning system and the cultural context where mobile learning occurs. In relation to HCI research field, socio-cognitive engineering (SCE) (Sharples et al., 2002) and contextual design (CD) (Beyer and Holtzblatt, 1998) are studying human activities and how to support them with technology.

Socio-cognitive engineering (SCE) includes the analysis of activities that sets constrains how people use current technology and secondly, the design of new technology (Sharples et al., 2002). According to contextual design, ethnographic methods are used for gathering data in the field studies to understand the workflows to be able to design human-computer interaction (Beyer and Holtzblatt, 1998). However, these approaches focus mainly on tasks and activities. Little is known how e.g. values (Cockton, 2008) or attitudes towards individualism (Hofstede, 2001) affect on tasks that are performed and should be supported by technology. Furthermore, in mobile learning context, research is needed on how to recognize the issues that may vary in different countries among learners with the same age and the same level.

We argue that investigation of cultural issues is crucial for designers to be able to understand what is important and valuable for users, or in our case, for learners, for their parents and teachers and principals in addition to the educational system.

In the field of the research of education, the situations of learning can be classified into four different types: formal learning (pupils have little control over the objectives or means of learning), non-formal learning (pupils control the objectives but not the means of learning); informal learning (pupils control the means but not the objectives of learning) and self-directed learning (pupils control both the objectives and means of learning) (Mocker and Spear, 1982). Learning with mobile devices could happen in anywhere at any time (Kukulska-Hulme et al., 2011). Also, the learning material that mobile devices provide could contain additional information or exercises, designed according to the specific curriculum. When exploring learning mathematics with mobile devices in South Africa, we focused on particularly on informal and formal learning. The learning material was developed according to the existing curricula in collaboration with South-African school personnel and service developers.

To understand the learning culture in South-Africa, we need to know the educational system. In 2009, there were 24693 public schools in South Africa (12 million pupils) and 1174 private schools (386098 pupils) (ICT for Teaching and Learning in South Africa, 2011). In addition, the student-to-teacher ratio in South Africa is high (see Table 1).

According to ICT for Teaching and Learning in South Africa (2011) student-to-teacher-ratio in private schools (primary, secondary, middle and combined) is 16 to 1. According to the 2003 Trends in Mathematics and Science Study (TIMMS, 2003), there is a challenge in mathematics teaching in South Africa. The international average maths score in 2003 was 467 whereas in South Africa it was 264. In addition, there is discrepancy in mathematics achievement across provincial, gender, economic and racial divides (TIMMS, 2003). For example, between 1999 and 2004, an average 4.4% of the matriculants achieved “mathematics passed adequate for entry into natural sciences at university level”. In 2006, only 4.8% passed higher grade 9 maths, (Fin24, 2008) and the prognosis for the matric classes of 2010 and 2011 was not much better.

To solve the challenges, several initiatives have established, focusing on training teachers to meet current and future requirements and ensuring that adequate measures for pupils to move from secondary education into higher education (HE) institutions or the labour market (JIPSA, 2008). However, the role of technology is not specified at all, thus leaving the field open for research into the possibilities offered by technology.

Table 1. Key figures in South Africa learning context

	South Africa
Inhabitants	Approx. 50 million
Student-to-teacher ratio (primary educ.)	30.71 to 1
Student-to-teacher ratio (secondary educ.)	30 to 1
Literacy rate (%)	88.72
Total enrolment/primary education (%)	89.43% (male), 90.66% (female)
Public vs. private schools	24693 public schools (12 million learners) and 1174 private schools (386098 learners)
Student-to-teacher ratio (primary educ.)	30.71 to 1

4. METHODOLOGY

In our research, we utilized a case study method based on data gathered by our industrial partner Nokia during 2008, 2009 and 2010. This longitudinal study was part of Nokia Mobile Mathematics -project conducted in South Africa for grades 9 and 10. The aim of the project was to help teachers and learners and also increase collaboration amongst learners and between teachers and learners through mobile technology intervention. The overall goal was to assess the feasibility of using mobile phones for teaching and learning mathematics. Based on the experiences during this process, our goal was to highlight the cultural issues that need to be considered in the design of mobile mathematics learning technology, especially in the cultural context of South Africa.

The longitudinal study was conducted in two phases during the years 2009 and 2010 (pilot tests were conducted in 2008). Table 2 illustrates the key figures related to the phases. Phase I started in February 2009 and ended in September 2009. Phase II started in October 2009 and ended in December 2010.

In the Phase I in 2009 there were altogether six schools (two in each of Gauteng, the North West, and the Western Cape) with pupils from grades 9 or 10 mathematics class in each school. The selection of schools was made by Nokia and the project team. Two different scenarios were planned considering the used technology: 1) use of low-level technology such as a short message service (SMS) and 2) use of higher-end technologies such as Mobile Browser and mobile social network platform MXit. The identified learning components for the two proposed scenarios included competitions, exercises, gaming, video clips, audio clips, collaboration, tutoring, SMS reminders, and test features.

During the Phase I, five of the selected schools, with 232 pupils in total, used the browser-based technologies (e.g. MXit) during 15 weeks. One school with grade 9, a class with 37 pupils, used SMS-based applications during seven weeks. There were altogether nine teachers who participated in the study in Phase I.

Several quantitative and qualitative methods were used for gathering the data in Phase I, for example: 1) questionnaires investigating teachers' and principals' attitudes, current ICT skills and ICT usage before and after the intervention, 2) questionnaires for learners (pupils) focusing on attitudes and experiences of mathematics learning before and after the intervention, 3) focus group interviews with teachers and pupils, 4) observations of lessons, and 5) thematic interviews with principals, teachers and pupils. The data was gathered twice: at the beginning of Phase I (during February and March) and at the end of the Phase I (in April).

During the Phase I in 2009, attitudes towards collaboration in learning were examined with a questionnaire (a six-point Likert scale from 1 = "Very strongly agree" to 6 = "Very strongly disagree") with 9 teachers and 232 pupils. In 2009, pupils' attitudes to mathematics and perceptions of value of technology use were measured twice, first in February and second time in April. The general attitude towards mathematics was measured using A Mathematics-Related Beliefs Questionnaire (MRBQ) (Op ´t Eynde, P. & De Corte, 2003). The data was analyzed with descriptive statistics and content analysis where appropriate.

In Phase II, the study was conducted in two cycles: the first from October 2009 to June 2010, and the second cycle from July 2010 to December 2010. The Phase II aimed in delivering high quality online mobile mathematics experience direct to South African learners. The focus was on delivering grade 10 mathematics content utilizing two technologies: 1) browser-based learning service (MXit) or as it was called social networking application (SNA) and 2) dedicated learning application (DLA) customized for download and use solely for the project. The learning content included bookwork with content explanations, examples, exercises, homework and questions of varying difficulty levels, hints to assist learners, and competitions. Teachers could use the exercise bank and theory for in-class teaching, follow-up, analyzing and monitoring how the pupils are doing with their exercises. Teachers could also collaborate with pupils e.g. by sending them reminders about homework or encouragement.

Table 2. Key figures in Phase I and Phase II

	Phase I	Phase II
Schools	6	30
Participants	241 (232 pupils, 9 teachers)	3991 pupils
Delivery channels	SMS and MXit	MXit and DLA
Duration	From 7 to15 weeks	From 8 to 15 weeks

Altogether there were 30 schools in the Phase II. 25 schools used SNA and five schools used DLA. Schools were selected randomly taking into account provincial spread. However, the selected schools had to meet specific criteria in order to participate, such as adequate GPRS network coverage in surrounding areas and principal's expression to be willing to support the project in their school. 12 of the chosen Phase II schools were in the Western Cape, 12 in the North West, and six in the Eastern Cape.

During the Phase II, there were altogether 3991 pupils who had registered themselves into learning services. However, only 1695 (43 %) were active users. Pupils were considered 'active' if they had completed a practice exercise or test using either of the mobile platforms.

Data collection methods in Phase II included: 1) questionnaires for teachers, principals and learners, 2) log files of the actual usage of the mobile learning systems, 3) interviews with principals and grade 10 mathematics teachers, 4) observations of lessons, and 5) focus group interviews with learners.

With the quantitative and qualitative research methods used during the longitudinal study, we obtained both objective and subjective data about the actual use of the mobile learning service and attitudes towards mobile learning. To understand what cultural issues need to be considered in the design of mobile mathematics learning technology, two of the researchers categorized the results in objective and subjective issues (e.g. Aykin, 2005; Ouygi et al., 2008).

5. RESULTS

Objective and subjective culturally sensitive aspects related to mobile learning were identified from the context.

5.1 Objective Issues

The first objective issue is the level of mobile network coverage, which is a fundamental requirement for mobile learning services. South Africa has the most advanced telecommunications network in Africa. This was a good starting point for developing mobile mathematics learning service in South Africa.

The second issue was the level of mobile penetration: in 2009, South Africa had 46.4 million mobile telephones in use, as well as 4.4 million internet users (ICT for Teaching and Learning in South Africa, 2011).

The third issue was the language used at school and pupil's level of that language. South Africa has about 50 million people of diverse origins, cultures, languages, and religions and eleven official languages are recognized in the constitution. Two of these languages are of European origin: English and Afrikaans. Although English is commonly used in public and commercial life, it is only the fifth most spoken home language. The education sector does not totally reflect the multilingual nature of South Africa. English is often used as the medium of instruction at the expense of Afrikaans and African languages (ICT Development Associated Ltd., 2011).

Fourthly, the content of the mobile mathematics material was aligned with the South African curriculum and level of maths. In a context where math results tend to decline substantially from Grade 9 to Grade 10 in South African Public Schools, the pupils who used the Nokia Mobile Mathematics service regularly (completing more than 15 practice exercises and tests) achieved results for Grade 10 were 7% better on average than their peers.

The fifth issue found is society's school system: e.g. are there public or private schools in the target area? What is the student-to-teacher ratio?

The sixth issue is how schools and education systems allow the use of mobile technology during school hours. In our study, 81% of the case study schools have an ICT policy or school code of conduct that restricts the use of mobile telephones during school time.

The seventh important issue was to understand how much pupils and teachers used the service. In 2009, 85% of the pupils had mobile phones with SMS capacities and 64% of them were able to use the browser based learning system with their mobile phones. The average posts per week for those pupils who used browser-based service was 3.99 posts per week and for SMS –based service users 1.69 per week. In 2010, there were altogether 2875 registered users and 1528 of them were active users. Of these pupils, 75% reported that they had their own mobile phones and 67% reported that their mobile phone could download browser-based service. In addition, 17% reported that they could access a shared mobile telephone, which could download browser-based service, at home. However, 13% of case study pupils were unable to use either their own or a shared mobile phone. Total views and post were 46989. At the beginning of Phase II in 2010, two technologies were in use i.e. SNA and DLA.

During the second cycle of Phase II, all the users were using the same SNA technology. Over one year, more or less than 102000 attempts were made on practice tests and examinations. In 2009, there were more than 53 logs per week for those teachers, who used the browser-based service. Only one teacher was using SMS-based learning service and had more than 39 logs per week. In 2010, there were 72 teachers who registered on the browser-based SNA system, which comprised Moodle for computer-based access and MXit for mobile access. As with the pupil numbers, there were fewer teachers who actually used the system, than those who registered on it. During the nine week period 48 teachers (66% of those registered) used the learning system (view and post). One teacher never used the system. Teachers who used the system could be categorized into rare users (less than ten view and posts per class), occasionally users (between 10 and 50 views and posts per class), frequent users (between 50 and 200 views and posts per class) and extensive users (more than 200 views and posts per class). The schools having teachers who were identified as frequent or extensive users were in three schools which had participated in the phase one intervention, i.e. these teachers were in their second year of making use of the platform.

In the other technology used in 2010, DLA, the 'total sent messages' reflected how many messages had been sent by the teacher to individuals using the system. These messages were mostly likely sent to a group (their class of pupils). The teachers in the DLA schools did not seem to use the system very much at all. In one school it was never used, in three schools it was very rarely used. The only real use by a teacher was evident in one school, where the teacher used the system to send six different messages, which meant a total number of 141 messages to their pupils.

5.2 Subjective Issues

Pupils' attitude towards mathematics is a subjective issue affecting the use of mobile learning technology. In the February 2009 measurement, most of the pupils seemed to be very confident about their skills in mathematics (weighted average pupil response 1.58 and SD 0.92). The second measurement was made in April and indicates a shift from the previous statements. The pupils still agreed with the statements, but less strongly. A notable shift was regarding the statement "I can usually do mathematics problems that take a long time to respond" towards greater agreement.

In relation to pupils' expectations, it seems that those, who used browser-based learning service, agreed strongly in February 2009 that they expect really enjoying using the mobile phone to help with mathematics. In April, they tend to agree less with these statements using "agreed" instead of "strongly agree". The pupils' attitude to mathematics seemed to improve as learning mathematics was seen enjoyable or fun. In April, pupils were strongly agreeing (weighted average 1.31 and SD 1.01) that "I think I will really enjoy/I enjoyed using my cell phone to help mathematics".

Pupils' attitude towards collaboration was another subjective issue related to the use of the service. Regarding the collaboration between pupils, in 2009 pupils' attitudes indicate that there was a great agreement with the statement "discussing different services to a mathematics problem is a good way of learning mathematics" and the agreement was even greater in April, when the attitudes were measured the second time. However, in 2009 the pupils also indicate that they are not primarily motivated to compare themselves with other students. In 2010, the maths chat facilities in the SNA for mathematics were developed late into the nine-week period. The type of activity use was analyzed from the views and posts for SNA pupils, over the nine-week period. This showed that most activity related to answering practice tests, viewing theory and answering tests. There was minimal use of the messaging and results facilities. The regular users most commonly indicated as some of the best features of the service social aspects such as the discussion wall, messaging and bulletin boards.

Teachers' attitudes towards mathematics were also a subjective issue affecting the use of mobile learning technology. In 2009, nine teachers' views about the impact on their pupils' attitudes to mathematics were asked with a four-point Likert-scale from "strongly agree" to “strongly disagree”. In February, of the teachers, 33 % strongly agreed and 67% agreed that the project “will significantly improve pupils’ attitude towards mathematics”. In April, 50 % strongly agreed and 50 % agreed with that same statement. In addition, teachers’ expectations and reflections on pupils’ competence in mathematics were explored with a four-point scale. In February, 33% of the teachers strongly agreed and 50% agreed that project “will significantly improve my pupils’ mathematics results”. Of the teachers, 17% choose “no comment” as their answer. In April, 17% of the teachers strongly agreed and 83% agreed with the same statement.

Teachers’ attitudes towards collaboration: Better communication possibilities at any given time seem to be one of the main strengths in the mobile math learning system according to teachers. Some teachers valued that they could communicate more with their pupils, especially outside of school working hours even during holidays and after school. However, only few teachers thought that the potential for collaboration amongst pupils is strength in using this particular learning system. Of those who see some collaboration possibilities argued that pupils could learn from each other, collaboration could lead to maths discussions and therefore for improved results and peer assessment as they will be able to chat with each other.

Teachers’ concerns: Teachers were asked about the inappropriate use of the mobile learning system and they reported that some pupils might become “addictive on chatting” and “unbalanced”. In addition, some teachers were concerned about pupils’ and their parents’ motivations, pointing out that it is important to convince the parents that mobile learning system can be used for good. In addition, teachers think that some parents may not allow their pupils to use the mobile learning system and may even accuse teachers of influencing their children negatively. This indicates that the parents should be informed carefully when adopting new technology to support learning at school.

6. DISCUSSION

In this study, we examined some cultural issues affecting the mobile mathematics learning service. From the designer’s point of view some of the culturally sensitive issues are easy to identify. They are objective issues such as a language and writing system of the service, mobile phone penetration and network coverage, the local school system affecting how to implement mobile service into the existing school system and how to adapt it to match the local curricula of maths. The level of maths in the targeted age group was important to know for designing the content as well as teachers’ level of ICT literacy. Based on the results, we present in Table 3 a number of design questions related to objective cultural issues. We suggest that designers consider these questions before designing mobile learning systems in school context.

In South African environment it was found that it is important to encourage the informal use of the service as the churn rate of teachers at school is high and the information disappears when a teacher leaves the school. This finding encouraged the development of the service towards a more informal way of using it: independently and outside school hours. Because of the low teacher-to-pupil ratio in public schools, mobile learning service could help teachers to keep up with the pupils’ learning progress as well as give teachers more ways to communicate with the pupils than in a traditional set up.

As mentioned earlier, in the study of culture in anthropology, a longer period of study is encouraged to find out the “natives point of view” (Czarniawska-Joerges, 1992; Iivari, 2004; Keesing & Stratherm, 1998; Smircich, 1983). We suggest that mobile learning and its effect needs to be evaluated during longer periods of time because taking new learning technology into use takes time. With longer user studies attitudes towards new technology can be recognized and measured and results of how technology is being used can be studied. Also, the learning results can then be measured. We want to emphasize in the context of mobile learning that researchers should pay more attention to the organizational culture, i.e. school norms and values, when adopting new technologies. In our case, nearly every school had written regulations that forbid pupils using mobile phone during the school days. This inevitably has an effect on the attitudes on using mobile devices for learning during school days.

There are some limitations in our study. Previous studies have shown (Chu et al., 2010; Motiwalla, 2007) that regarding the relationship between learning outcomes and usability of the system, the cognitive load of using the system is an important factor. Therefore, in the future standardized measurement tools for examining both pupils and teachers’ cognitive load should be conducted.

7. CONCLUSION AND FUTURE WORK

In this paper, we aimed to present the results of a research on the effect of cultural context on user experience of mobile mathematics service. The aim of our study was to identify culturally sensitive areas in the local context of mobile learning services in order to give insight for localization of these services. Our research focused on a large scale and longitudinal study of learning mathematics by mobile phones amongst secondary school teachers and pupils in South Africa. Our main research questions in this paper were: what cultural issues need to be considered in the design of mobile mathematics learning technology? We argue that both objective and subjective aspects according to existing cultural models should be analyzed. We also present design questions that can help in the design of mobile learning services for school context (see Table 3).

Table 3. Proposed design questions to help the design of mobile learning services for school context

What language is used at school? What language is used at home?
What is the pupils’ level of that language used at school? Does it have implications to design e.g. does more simple language need to be used in the content?
Does the content need adaptation to the local curricula and level of maths?
What would be the best target age for the learning service?
How to implement mobile service to the existing school system?
Who is responsible for taking the system into use, maintaining it and plan the use to be part of the school day?
What kinds of instructions are needed?

In the research of learning in different cultures in mobile learning context it is important to study the service use over the longer period of time to see the results of learning, to find out how the new way of learning is taken into use and how it is accepted by teachers and pupils.

Also, longitudinal study is required in order to see a possible change in attitudes towards and motivation to use new technology. The research of cross-cultural issues in these areas support service developers to understand the local contexts, which is a vital issue when the main aim is to integrate mobile learning into the everyday processes of an ordinary school day in different countries with a different cultural background.

More research is needed in the area of collaborative and informal m-learning in different cultures. Therefore, we will continue to study the localization requirements for mobile mathematics service, looking into topics such as a) Concept (e.g. motivation, attitudes towards maths, formal/informal learning), b) Content (e.g. the support of the software for the writing systems), c) Technology (e.g. what kind of support is offered for the service in the country), and d) Infrastructure (e.g. level of maths, the school system). Our next study focuses on motivational factors related to the longitudinal use of mobile math learning services, such as Nokia Mobile Mathematics, in South Africa and other African countries.

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