

Oppimisen mobiili ulottuvuus yleissivistävässä koulutuksessa

teknologinen ja pedagoginen näkökulma

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Sisältö

1. Introduction	6
1.1. Visions and starting points	6
1.2. Research question	8
References	10
2. A theory of mobile learning: Sharples theory	12
2.1. Learning as Conversation	14
2.2. Context and learning	17
2.3. The dialectical relationship between learning and technology	17
2.4. Usage of the task model for mobile learners	19
2.5. Task model and my mobile experiments.....	22
2.5.1. Revision of probability calculation with SMS-messages and MLE.....	22
2.5.2. Biology exam in the woods with MLE-Moodle.....	23
References	24
3. Design-science	25
3.1 The building process.....	25
3.1.1 The specification process	26
3.1.2. The implementation process.....	26
3.1.3 Purchasing a ready-made artifact or making it from existing parts	27
3.1.4 Parallel specification and implementation processes	27
3.2 Evaluation of innovation.....	27
3.3. Guidelines for design science research	28
3.2.1. Guideline 1: Design as an Artifact.....	29
3.2.2. Guideline 2: Problem Relevance.....	29
3.2.3. Guideline 3: Design Evaluation	29
3.2.4. Guideline 4: Research Contributions.....	29
3.2.5. Guideline 5: Research Rigor.....	30
3.2.6. Guideline 6: Design as a Search Process.....	30
3.2.7. Guideline 7: Communication of Research	30
3.3. A Three Cycle View of Design Science Research	31
3.4. The Ethics of Design Science.....	35
3.5. Ongoing discussion about design science	37

References.....	38
4. The first cycle.....	40
4.1. Building of the artifact.....	40
4.2. Evaluation of the artifact.....	42
5. The second cycle.....	45
5.1 Building of the artifact.....	45
5.2 Evaluation of the artifact.....	45
6. Deeper evaluation after cycle one and two	47
6.1. Why students chose mobile way to use MLE? How SMS-users and WWW-users are different from their backgrounds?.....	50
6.2. What is the influence of chosen user interface to the attitudes of students to the MLE?	52
6.3. Gender impact to certain variables	54
6.4. Some correlations.....	57
6.5. Reliability and factor analysis	60
6.6. Lessons learned from cycle one and two – what’s next?.....	62
7. The third cycle	64
7. 1 Building of the artifact.....	64
7.1.2 Kannel and SMS.....	64
7.1.3 Kannel configuration for MLS-server.....	65
7.1.4 Mbuni and MMS.....	67
7.1.5 Mbuni configuration for MLS-server	69
7.1.6 MLE	71
7.2. Evaluation of the artifact.....	74
7.2.1 Competition: Who founds the biggest tree of the forest?.....	74
7.2.2. A MMS-blog of religion course and MMS- excursion diary.....	74
References.....	76
8. The fourth cycle: making MLE ready for production use	77
8.1 Building of the artifact.....	77
8.1.2 Server core platform.....	78
LAMP.....	78
Raid and rdiff	78
Mail server : Postfix and Squirrelmail.....	78
Proxy: Squid and DansGuardian	79
Safety tools against spam and viruses: SpamAssassin and Clam AntiVirus	79

Firewall	80
8.1.3 Mobile application platform.....	80
8.1.4 Mobile learning environment MLE.....	80
8.1.5 Extension of MLE	80
Sources	80
8.2 Evaluation of the artifact.....	82
8.3 MMS-messages in the teaching of mathematics	85
8.3.1. Mobile learning and mathematics.....	85
8.3.2.The anatomy of MMS-messages	85
8.3.3.Using MMS in mobile learning	86
mediaBoard	86
Lecture feedback system with MMS	86
8.3.4.How to build a MMS-message with mathematical content?.....	87
8.3.7. Background information about students in these experiments	88
8.3.8. Technical problems with MMS	92
8.3.9. Main results	92
8.3.10. Comparison between the student's attitudes to the traditional web learning environment Moodle and the new mobile learning environment MLE	93
8.3.11. Correlations	94
8.3.12. Men and women	96
8.4. Tekstiviestit ja tiedotus lukiossa.....	97
8.4.1. Aiempaa tutkimusta	97
8.4.2.Tarve Suomen lukioissa	98
8.4.3 Konstruktio ja sen käyttö.....	99
8.4.4. Tutkimusongelmat.....	99
8.4.5 Opettajakysely	99
8.4.6 Opiskelijakysely	100
8.4.7 Tilastollista analyysiä	103
Varianssianalyysiä.....	103
Korrelaatioanalyysiä	104
8.4.8 Johtopäätökset	105
Viitteet.....	105
9. The fourth cycle: Binder-Opit	106
9.1 Moop	106

9.3. Case 1: forestry education task course	109
9.3.1. Making of the tasks and courses	109
9.3.2. Technology	110
9.3.3 Survey for pupils	110
9.3.4 Teacher's feedback	115
9.4. Case 2: Museum	115
9.4.1 Survey for pupils	118
9.4.2 Teacher's feedback	122
9.5. Lessons learned	122
Sources	123
10 The fifth cycle: MLE-Moodle	124
10.1. Past projects with MLE-Moodle	126
10.2 Our Moodle server with MLE-support	127
MLE-Moodle	127
10.3. Case 1 - museum education	127
10.4. Case 2 – biology exam in the woods	130
10.4.1 The tasks	130
10.4.2 Technology	130
10.4.3. Survey for pupils	133
10.5. Lessons learned	136
11. Similar projects	138
11.1. MobilED Platform	138
11.2 A Platform for Server-Side Support of Mobile Game-Based Learning – mGBL	139
12. Discussion	141
12.1. Summary of main results	141
12.2. Implications of the results: Guidelines for ordinary Finnish schools starting mobile learning	141
12.3. Future research	141

1. Introduction

1.1. Visions and starting points

“Wireless or mobile technology is part of everyday life of pupil in basic education in the next five years ... It is clear, that device in pupil’s schoolbag is not yet in stores. Educational use of this device is grounded on the use of text and photos.” Jari Koivisto from The Finnish National Board of Education 2003

This vision of Jari Koivisto was one of the starting points of my research, when I was in year 2004 trying to find a good subject to my doctoral thesis.

As background I have four year participation in The Finnish Virtual School project. The Virtual School project was launched in 1999 with the aim to develop the flexibility and diversity of the Finnish school system making use of ICT. The Virtual School project consisted of several development projects carried out in co-operation between education authorities, education providers and schools in order to develop and produce study modules, support services and learning materials. In Lempäälä municipal we had worked with many technologies and projects: Netmeeting video conferencing, WWW-materials with FrontPage, doing surveys in the Internet, intranet servers with Linux, video-editing, video-projectors to classrooms and so on.

I was worked about 8 years as teacher of mathematics but also about two years in Nokia Networks working with databases of digital switching platforms so I have a quite good basic knowing of mobile technology. Mobile learning was a natural choice for research area.

There have been some first mobile learning experiments in Finland in the early years of millennium.

Wireless Future School research project started 2002 in The Practising School of Teacher Education Department in Hämeenlinna. 25 pupils (age 11) got a personal laptop with wireless Internet access and local area network connection (WLAN). Pupils also have mobile Internet connection everywhere they go on via GPRS connection. Everything was free for the pupils and their families. (Horila 2004)

In Pirkkala and in Turenki a 6th grade classes used eight iPAQs in the schoolwork during the school year 2003-2004 in three-week periods at a time. The devices have had extra accessories like Com pact Flash cameras, detachable keyboards and the General Packet Radio Ser vice (GPRS) connections. The main working method was teamwork be cause of the small amount of the devices. (Saarinen 2004)

In Häme Polytechnic they studied how material and the www sites of Häme Polytechnic work with PDA devices. The testing of the websites and study material was done with PDA device furnished with a Pocket PC operating system. The device was used for testing, eg, available e-learning environments, different document formats, video lectures and the use of email. The thesis also included user tests to students on the utilization of study material with the PDA. The intention of the study was to find out how the students reacted to studying with the PDA device from the technical and usability perspective.(Siira 2003)

In Advanced Multimedia Center (a research laboratory in Tampere University of Technology, Pori) was implemented 2002 platform adaptive learning environment, xTask. xTask can be accessed by PC's or mobile devices, such as PDA's or Communicator. The environment was tested with 20 Finnish high school students who were participating in an alternative art course. The students were provided with mobile devices that they were meant to use during their museum visit. PDA's allowed the students to make both audio and text notes about the pieces on display in the art museum. Two of the mobile devices were built especially to record video and sound notes. With all of these devices the students were able to make a number of different notes in different media formats, and were able to send them directly to their personal folder in the xTask environment. (Ketamo 2003, Haaparanta 2005)

In the European level research and development of mobile learning was going forwards rapidly. One early European project was HandleR. At the University of Birmingham developed a Handheld Learning Resource HandLeR that can assist people of all ages in their personal learning throughout a lifetime. One of the use scenarios was like this:

"An 11 year old child is on a school field trip. She captures images of an historic site, annotates these with notes and sketches and organizes them into a visual idea map. The child extends the idea map by adding pages from an internet guide to the site and its history, accessed through a high-speed wireless network around the building. She then merges parts of her map with those of the other children to create both a personal and a group website of the visit."

The hardware for the prototype system consisted of a Pen Tablet computer containing a 8.4 inch 800 x 600 SVGA display with a touch sensitive screen and a 233MHz Intel Pentium processor running the Windows 98 operating system. (Sharples 2002) An important conclusion from trials of the HandLeR system was that the technology at that time had severe limitations which made it almost impossible to use. (Kukulska-Hulme 2009)

MOBIlearn was a worldwide European-led research and development project started 2002 exploring context-sensitive approaches to informal, problem-based and workplace learning. Its aim was to develop, implement, and evaluate an architecture for mobile learning, based on theories of effective teaching and learning in a mobile environment. The focus of the project was to develop and support learning outside the classroom, including learning in museums, studying for a workrelated MBA, and gaining basic medical knowledge. One consequence of the MOBIlearn project was a shift in focus from learning with handheld devices, towards support for the mobility of learning. (Kukulska-Hulme 2009)

M-learning was a 3 year pan-European research and development programme launched 2001, aimed at helping young adults aged 16 to 24, who were considered most at risk of social exclusion in Europe. The project developed a Learning Management System and a microportal interface to provide access to learning materials and services from a variety of mobile devices, web and TV. Applications included an authoring system to create and deliver SMS quizzes for topics such as health information and drugs advice, mobile phone games, for example to allow learner drivers to practise driving theory questions, and a media board for learners to build online web pages by sending messages, pictures and audio from their phones. One lesson learned from project was, that the best way to get started with developing mobile learning is to try it in practice through trial and experiment with simple tools. (Kukulska-Hulme 2009)

Web-pages of both important European projects are still in the web : <http://www.mobilelearn.org/> and <http://www.m-learning.org/> .

1.2. Research question

The University of Birmingham hosted the first international conference on mobile and contextual learning in June 2002. This led to the international mLearn conference series. In 2004 it was possible to me to read some articles from proceedings of mLearn 2003 and mLearn2004. My conclusion from ongoing research was that there was a lot of research with PDA:s and smart phones and adult learners using them, not so much with basic mobile phones own by pupils under 18. I was a teacher of Lempäälä Senior Secondary School , so my school and students would be a good environment for doing some mobile learning trials with simple tools.

My main research question is this: Is there in the near future any possibilities to wide use of mobile learning in basic education and upper secondary schools in Finland? With wide use I mean same kind of use that there is nowadays with traditional ICT in schools. I research mobile learning as a part of electric learning, which has over 30 year's history in Finnish school system. Besides learning use I also research counseling and announcement use of mobile tools.

Why was not mobile learning emerged from its project status and entered into mainstream education and training in the middle of first decade on 2000 century? Only 14% of distance educators (88 responses from 27 countries) were reporting that their institutions indeed have developed course materials for use on mobile devices. (Zawacki-Richter 2006) Keegans opinion was that mobile learning is not seen as a satisfactory revenue stream by the telecommunications operators (Keegan 2005). But is adding business to mobile learning only solution? How about open source and technical innovations that make mobile learning as cheap as possible and easy to take in use?

I stated that mobile learning is not in mainstream, because we had lack of mobile infrastructure in schools. We need introduce pedagogy of mobile learning to ordinary schools, but also pure technology is needed. In the field of learning technology we can't go the pedagogy without technological infrastructure.

I wanted to build a pedagogically and technologically realistic model of wide use of mobile learning. It was clear, that if we want wide use of mobile learning, as mobile clients we shall use student's own mobile phones, because schools don't have extra money to buy to all students' smart phones or PDAs. That's why in design of mobile environment we shall first restrict to young people's favorite phones, which have SMS, MMS, GPRS, Wap/XHTML and mobile email. When price of smart phones is coming down and students (and their parents) have afford to these "little computers", possibilities of mobile learning grow exponentially.

Basic mobile phone is not very intelligent device – it is a very thin client. But when a basic mobile phone is combined with web-server technology, it can be used as interactive and collaborative learning device very efficiently. Problem was in year 2004, that there was not available any open source or commercial mobile learning environment. **So if I want to research mobile learning as phenomena, I must first to build the mobile learning system myself. That is why natural choice for main research method was design science.** In design science can be asked, is it possible to build some innovation and how useful the innovation is. Design science comprises of two basic activities, build and evaluate. Building is a process of constructing an artifact or innovation for a specific aim. Evaluation is a process of determining how well the artifact performs. **My aim was, that evaluation part of design science research should done so well,**

that we get also general findings on mobile learning phenomena in basic education and upper secondary schools.

My design science artifacts are the mobile learning server and the mobile learning environment. When I started to implement these artifacts, my aim was that these must be constructed with low cost and that use of them must also be cheap for school and pupils. Wide use of mobile learning is not possible, if costs are great.

Mobile learning server (MLS) consists of two parts, server core platform (SCP) and mobile application platform (MAP). MLS is not important as itself. There is a lot of “technology toys”, which doesn’t change world of learning and it is possible, that MLS is one of them. MLS is however potentially important, because it makes possible to rapidly and easily to construct applications for mobile learning which together constitutes a mobile learning environment (MLE).

MLS relies on open source technology and open content. Server core platform and mobile application platform is build from existing and reliable open source components. First parts of MLE that I have constructed are also open source that I licensed with free GPL license. Exercises I created to mobile learning experiments are open content. I hoped that there will be some day a community of software developers and teachers interested of mobile learning that will together develop MLE and its pedagogical use.

I have published specifications and exact building instructions of MLS in my blog vps.virtuaalikoulu.org/mle. With these instructions schools teacher of information technology or it-support person can build own server and teachers can begin to use MLE and develop own models of using mobile learning.

There were a lot of changes in these seven years of research.

1. First commercial mobile learning environment was getting available in Finland, Opit-Binder.
2. Web based learning environments like Moodle was getting more usual in Finnish upper secondary schools, so need for integration of mobile and traditional web based learning was obvious.
3. First open source mobile learning environment was getting available and it does this integration with web based learning, MLE-Moodle.
4. Social media like Facebook and digital music service Spotify made a break through. There is a need for pupil’s to use services like this also mobile way and so there is also need for 3G data with a fixed price with her mobile operator. Future of mobile learning may be in mobile data connections, not in messaging systems?
5. New mobile devices like Mini Laptops and Tablet Pcs came to markets.

I wanted also to compare my own MLE environment to these new products Opit-Binder and MLE-Moodle, so I made also some evaluation by field testing with them.

References

Horila 2004

Horila, M., Tammi, T. Langaton tulevaisuuden koulu. Raportti. Hämeenlinna: Tampereen yliopisto, Hämeenlinnan normaalikoulu, 2004. 37 s. Saatavissa

http://www.uta.fi/laitokset/normaalikoulu/langaton/langaton_0504.pdf

Journal of Computer Assisted Learning (2003) 19, 360-370 Blackwell Publishing Ltd

xTask – an adaptable learning environment environment

H. Ketamo

MOBILE TECHNOLOGIES AND EDUCATION

A Case Study at the Pori Art Museum

Heikki Haaparanta and Harri Ketamo

[E-Training Practices for Professional Organizations](#)

[IFIP Advances in Information and Communication Technology](#), 2005, Volume 167/2005

Sharples, M., Corlett, D. & Westmancott, O. (2002). The design and implementation of a mobile learning resource. *Personal and Ubiquitous Computing*, 6(3), 220–34.

Saarinen J. 2004

eValuator Evaluation Tool For Digital Learning Materials, Environments And Mobile Learning

http://dll.hamk.fi/dl2/filet/eValuator_english_version.pdf

Siira 2003

Mobiilioppiminen ja PDA-laitteen hyödyntäminen opiskelussa

<http://dll.hamk.fi/dl2/filet/MiljaSiiraOpinnaytetyo.pdf>

Kukulska-Hulme, Agnes; Sharples, Mike; Milrad, Marcelo; Arnedillo-Sánchez, Inmaculada and Vavoula, Giasemi (2009). Innovation in Mobile Learning: A European Perspective. *International Journal of Mobile and Blended Learning*, 1(1), pp. 13–35

Zawacki-Richter, Brown, 2006. *Mlearn 2006*

http://auspace.athabascau.ca:8080/dspace/bitstream/2149/1258/1/Zawacki-Richter_Brown_Delport+mlearn06.pdf

Keegan, 2005.

THE INCORPORATION OF MOBILE LEARNING INTO MAINSTREAM EDUCATION AND TRAINING

<http://www.mlearn.org.za/CD/papers/keegan1.pdf>. Mlearn 2005

Mäntylä 2005

https://jyx.jyu.fi/dspace/bitstream/handle/123456789/12779/URN_NBN_fi_jyu-2005435.pdf?sequence=1

2. A theory of mobile learning: Sharples theory

Every era of technology has somewhat formed education in its own image. There is a convergence between the main technological influences on a culture and the contemporary educational theories and practices. In the era of mass print literacy, the textbook was the medium of instruction, and a prime goal of the education system was effective transmission of the canons of scholarship. During the computer era, education has been re-conceptualized around the construction of knowledge through information processing, modeling and interaction. Now there is a growing interest in the relations between mobile technology and learning. There is a need for a suitable theory of education for the mobile age. (Sharples 2007)

What is special about mobile learning compared to other types of learning activity? The obvious difference is that it starts from the assumption that learners are continually on the move:

1. We learn across space as we take ideas and learning resources gained in one location and apply or develop them in another.
2. We learn across time, by revisiting knowledge that was gained earlier in a different context, and more broadly, through ideas and strategies gained in early years providing a framework for a lifetime of learning.
3. We move from topic to topic, managing a range of personal learning projects, rather than following a single curriculum.
4. We also move in and out of engagement with technology, for example as we enter and leave mobile phone coverage. (Sharples 2007)

A theory of mobile learning must embrace the considerable learning that occurs outside offices, classrooms and lecture halls. Vavoula (2005) studied everyday adult learning based on personal learning diaries. He found that almost half of the reported learning episodes took place away from home or the learner's own office, i.e. the learner's usual environment. The learning occurred in the workplace outside the office, outdoors, in a friend's house, or at places of leisure. Other locations reported included places of worship, the doctor's surgery, cafes, hobby stores, and cars. (Sharples 2007) This potentiality must also be used in primary and secondary schools.

A theory of learning must be based on contemporary accounts of practices that enable successful learning. A synthesis (made by The US National Research Council) of research into educational effectiveness across ages and subject areas concluded that effective learning is:

- learner centred: it builds on the skills and knowledge of students, enabling them to reason from their own experience.
- knowledge centred: the curriculum is built from sound foundation of validated knowledge, taught efficiently and with inventive use of concepts and methods.
- assessment centred: assessment is matched to the ability of the learners, offering diagnosis and formative guidance that builds on success.
- community centred: successful learners form a mutually promotive community, sharing knowledge and supporting less able students.

These findings broadly match a social-constructivist approach, which views learning as an active process of building knowledge and skills through practice within a supportive group or community. (Sharples 2007)

A theory of mobile learning must take account of the ubiquitous use of personal and shared technology. By the end of 2010, there was an estimated 5.3 milliard mobile cellular subscriptions worldwide, including 940 million subscriptions to 3G services. Access to mobile networks is now available to 90% of the world population and 80% of the population living in rural areas. (ITU 2011)

These figures indicate a trend towards ownership of at least one, and for some people two or three, items of mobile technology including mobile phones, cameras, music players and portable computers. A trend relevant to a theory of learning in the mobile world is that some developing countries, particularly in sub-Saharan Africa, are by-passing fixed network telephony to install mobile phone networks in rural areas. These offer the opportunity for people in rural communities not only to make phone calls, but to gain the advantages of mobile services such as text and multimedia messaging. (Sharples 2007)

Few last years' we have seen convergence of mobile technologies, when into a single device has been combined the functions of phone, camera, media player and multimedia wireless computer. Another convergence is occurring between the new personal and mobile technologies and the new conceptions of learning as a personally-managed lifelong activity. (Sharples 2007)

New Learning	New Technology
Personalised	Personal
Learner centred	User centred
Situated	Mobile
Collaborative	Networked
Ubiquitous	Ubiquitous
Lifelong	Durable

Sharples (2007) definition of mobile learning is ‘the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies’. The focus of definition is not the learner, nor their technology, but the communicative interaction between these to advance knowing. Central to Sharples definition is the claim that conversation is the driving process of learning: “It is the means by which we negotiate differences, understand each other’s experiences and form transiently stable interpretations of the world.” (Sharples 2007)

2.1. Learning as Conversation

The one background of Sharples theory is the Pask's Conversation Theory, which describes learning in terms of conversations between different systems of knowledge. Pask didn't made any distinction between people and interactive systems such as computers. The theory can be applied equally to human teachers and learners, or to computer based teaching or learning support systems.(Pask 1976, Sharples 2002)

Let us begin with a student engaged in some activity in the world, such as carrying out a chemistry experiment, or solving a mathematical problem, or exploring a museum or forest. As the student performs the activity he or she tries out new actions, reflects on how these work and makes decisions about what to do next (Fig. 2). The person is actively constructing an understanding of the activities. There is continual interaction and adjustment between the person's thoughts and actions. To gain from that experience, to perform it differently or better in future, the learner needs to form a description of themselves and the activities, to explore and extend that description and to carry forward the understanding to a future activity. That is the minimum requirement for any person, or any system, to learn: it must be able to converse with itself about what it knows. (Sharples 2002)

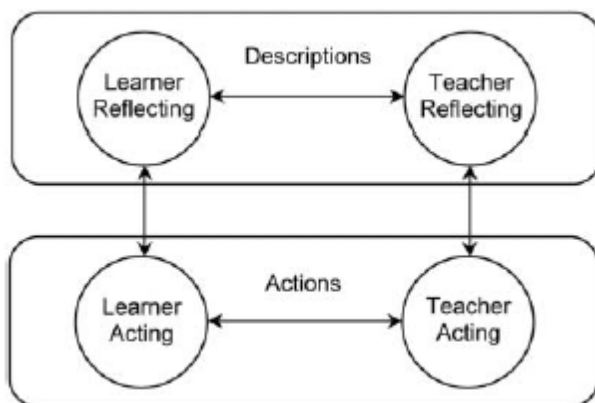


Fig 2.

Suppose that for example a student and a teacher (or two students) are working together on a project. Both people are interacting with the world and conversing at the level of actions – “look here”, “what’s this?”, “do that”. They are also conversing at the level of descriptions by exchanging reflective descriptions of their knowledge: “what do you think of this?”; “why do you do that”? The two people share an understanding if Person A can make sense of B’s explanations of what B knows, and person B can make sense of A’s explanation of what A knows. Thus, it is through mutual conversation that we come to a shared understanding of the world. Learning is a continual conversation: with the external world and its artefacts, with oneself, and also with other learners and teachers. (Sharples 2002)

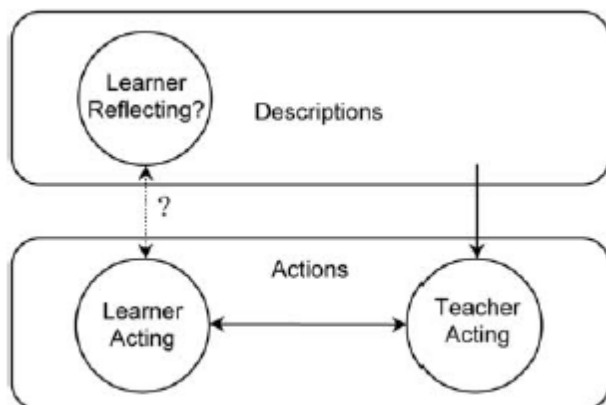


Fig. 3

What place is there for technology within this theory? One possibility is for the computer to take the place of the teacher (Fig. 3). That is traditional computer-aided instruction, but unfortunately it only covers part of the conversational space. The computer can hold a limited dialogue at the level of actions: “look here”; “what’s this?”; “do that”, but is not able to reflect on its own activities or its own knowledge. And because it cannot hold a conversation at the level of descriptions, it has no way of exploring students’ misunderstandings or helping them to reach a shared understanding. (Sharples 2002)

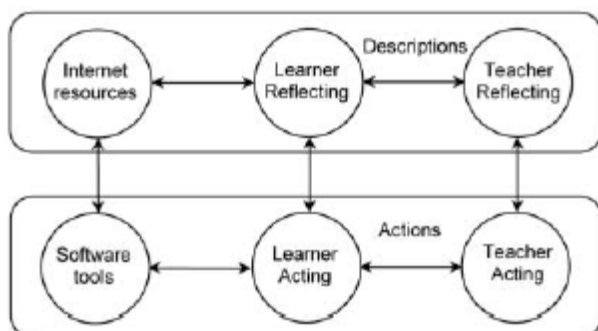


Fig. 4

The technology can also provide an environment in which conversational learning takes place, that enables conversations between human learners (Fig. 4). Networked devices can extend the range of activities and the reach of a discussion, into other worlds through games, software models and simulations and to other parts of this world by using the computer as a means of communication, through phone, email and computer based discussions. (Sharples 2002)

Sharples (2007) and Laurillard (2002) have given more detailed version of her framework for learning as conversation. (Fig. 5) Laurillard proposes that for learning to succeed, the student must:

- apprehend the structure of the discourse
- interpret the forms of representation
- act on descriptions of the world
- adjust actions to fit the task goals

- adjust descriptions to fit the topic goal
- reflect on the cycle of goal, action, feedback

Some educational activities, such as chemistry and physics lab classes, are designed to support this structure of conversation. Most conversations cover only one part of the framework, either because the learner has no conversational partner available, or there are no tools for model building to hand, or learners lack the language and concepts to converse at the level of descriptions. That is where technology can assist. (Sharples 2007)

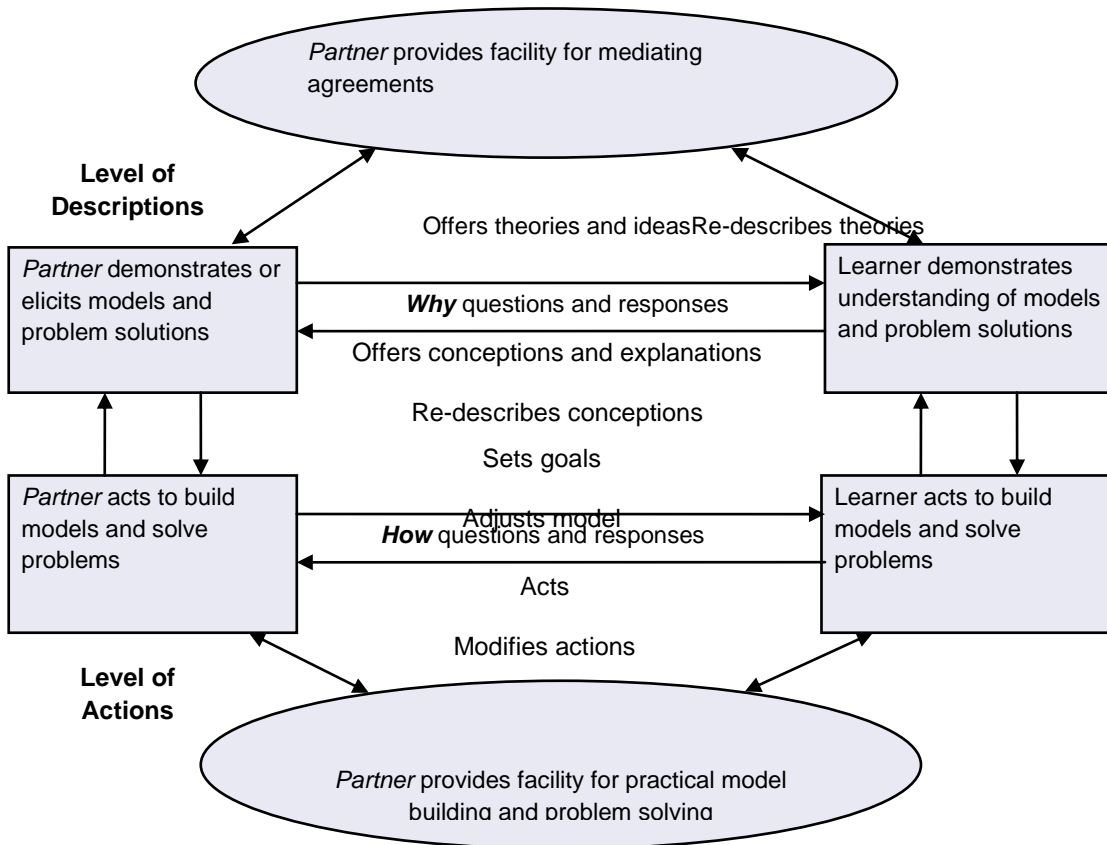


Fig. 5

2.2. Context and learning

All activity is performed in context. There must be distinction between context as “that which surrounds us” and context as “that which weaves together”. Same distinction has been made in the technical literature on pervasive computing between context as a ‘shell’ that surrounds the human user of technology and context as arising out of the constructive interaction between people and technology. (Sharples 2007)

The ‘context as shell’ model situates the learner within an environment from which the senses continually receive data that are interpreted as meaningful information and employed to construct understanding. Thus, a learner in a classroom may receive information from a teacher, a whiteboard and a text book, all of which must be assimilated and integrated to form a composite understanding of the topic being studied.

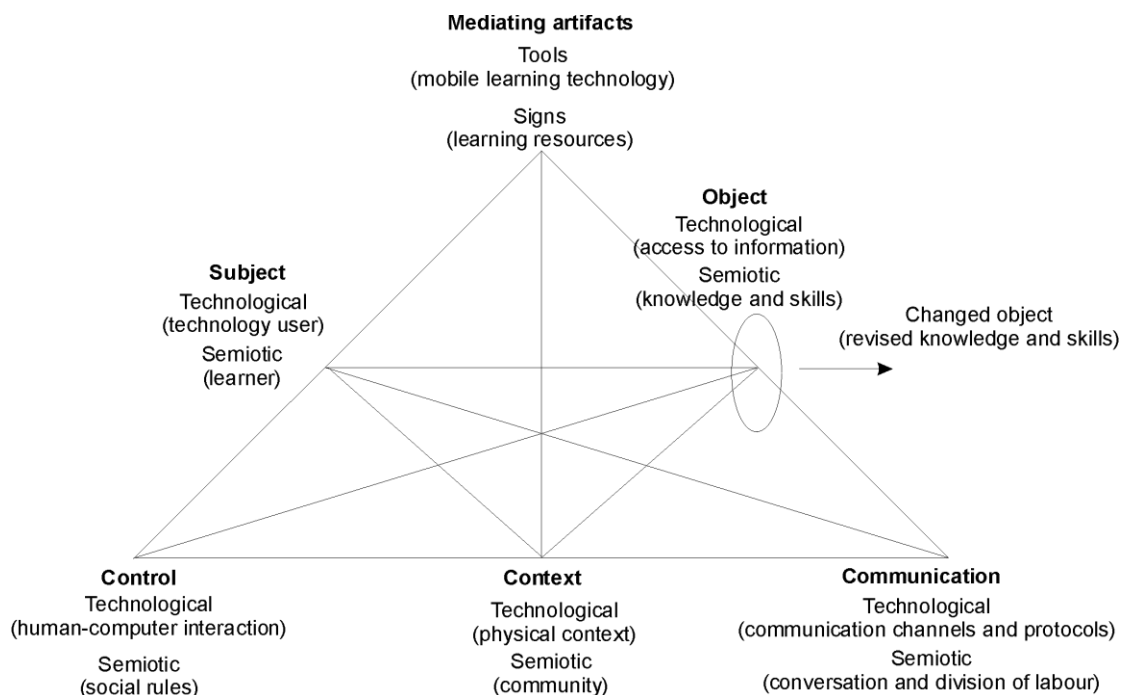
But learning not only occurs in a context, it also creates context through continual interaction. The context can be temporarily solidified, by deploying or modifying objects to create a supportive workspace, or forming an *ad hoc* social network out of people with shared interests, or arriving at a shared understanding of a problem. But context is never static. The common ground of learning is continually shifting as we move from one location to another, gain new resources, or enter new conversations. (Sharples 2007)

Traditional classroom learning is founded on an illusion of stability of context, by setting up a fixed location with common resources, a single teacher, and an agreed curriculum that allows a semblance of common ground to be maintained from day to day. If all these are removed, as may be the case with learning in the mobile age, then creating temporary islands of relatively stable context is a central concern. In this respect, the historic construction of context, the process by which we arrive at current understanding, assumes greater importance. (Sharples 2007)

“For example, a visitor to an art gallery stands in front of a painting. She has arrived at a current understanding of the painting from the path she has taken through the gallery – taking in the ambience, stopping at other paintings, reading the guidebook – and also from a lifetime of creating and interpreting works of art starting with childhood drawings. In one sense, context can be seen as an ever-playing movie, with each frame of current context being a progression from earlier ones and the entire movie being a resource for learning. But it is a movie that is continually being constructed by the cast, from moment to moment, as they share artefacts and create mutual understanding through conversation.” (Sharples 2007)

2.3. The dialectical relationship between learning and technology

Sharples has characterized learning as a process of coming to know through conversation across continually re-constructed contexts. The role of computer and communications technology is important in that process. The study by Vavoula showed that 52% of everyday learning episodes involved one or more pieces of electronic technology: mobile and fixed phones, laptop and desktop computers, televisions and video recorders. To support mobile learning according to Sharples definition, it is not necessary that the device itself be portable, also mobility of people and knowledge is included to definition. (Sharples 2007)



The upper part of the triangle of Figure 1 contains the three standard factors: the learner (subject), the learning goal (object) and the tools that are used to mediate the learning goals to the learner. For instance, tools can be the teacher, a book, a text, a learning-video, an e-learning-module and even an environment and its objects, or a certain situation. The model extends the standard factors on the baseline of the triangle by three influencing factors context, control and communication which are very relevant for Mobile Learning. Each factor is connected to all other factors, symbolizing the dynamic and complex interdependencies among them. (Frohberg 2009)

Sharples analyses learning as a cultural-historical activity system, mediated by tools that both constrain and support the learners in their goals of transforming their knowledge and skills. To explain the role of technology in learning Sharples separates two perspectives, or layers, of tool-mediated activity. The semiotic layer describes learning as a semiotic system in which the learner's actions to promote an objective are mediated by cultural tools and signs. The technological layer shows learning as an engagement with technology, in which tools function as interactive agents in the process of coming to know, creating a human-technology system to communicate, to mediate agreements between learners (as with spreadsheets, tables and concept maps) and to aid recall and reflection (as with weblogs and online discussion lists). Layers must be seen separately because the same technology setting can be used for different educational approaches, and vice versa, the same educational approach can be achieved with different technology settings. A semiotic framework promotes discussion with educational theorists to analyse the activity and discourse of mobile learning and a technological framework for software developers and engineers to propose requirements for the design and evaluation of new mobile learning systems. The layers can be also superimposed, to examine the holistic system of learning as interaction between people and technology. (Sharples 2007, Frohberg 2009)

Control

The control of learning may rest primarily with the teacher, or it may be distributed among the learners. Control may also pass between learners and technology, for example in a dialogue for computer-based instruction. The technological benefit derives from the way in which learning is delivered: whether the learners can access materials when convenient, and whether they can control the pace and style of interaction. (Sharples 2007)

Technology use occurs within a social system of other people and technologies. Social rules and conventions govern what is acceptable (e.g. how to use e-mail, who is allowed to email whom, what kinds of document format should be used). A person's attitudes to technology can be influenced by what others around them think about it. (Sharples 2007)

Context

From a technological perspective there has been debate about whether context can be isolated and modelled in a computational system, or whether it is an emergent and integral property of interaction. Context also embraces the multiple communities of actors (both people and interactive technology) who interact around shared objectives, mutual knowledge, orientations to study, styles and strategies of learning. (Sharples 2007)

Communication

The dialectical relationship between the technological and semiotic layers is perhaps the easiest to see in relation to Communication. If a technological system enables certain forms of communication (such as email or texting), learners begin to adapt their communication and learning activities accordingly. For example people are increasingly 'going online' at home, creating networks of interaction through phone conversation, texting, email and instant messaging that merge leisure and work activities into a seamless flow of conversation. As they become familiar with the technology they invent new ways of interacting – 'smilies', text message short forms, the language of instant messaging – that create new rules and exclusive communities. (Sharples 2007)

"When faced with a new tool, people examine both the possibilities and constraints it offers. This leads to a process in which the users adjust the 'fit' of their tools to their activities. Sometimes tools will cause their users to change their own behaviour to accommodate a feature or shortcoming in the tool; sometimes users will shape the tool to suit their specific requirements. Doing either of these things may initiate further changes as the users begin to exploit the technology, hence the dialectical nature of the process." (Sharples 2007)

2.4. Usage of the task model for mobile learners

Frohberg has done a critical analysis of 102 Mobile Learning projects published before the end of 2007. The six factors in the framework (context, tools, control, communication, subject and object) enable describing mobile learning project in a structured way. In a first step, each factor can be portrayed separately and isolated, ignoring the complex interdependencies between factors. Assembling all factors

within the triangle produces a complete picture for a specific instantiation of a project. A dynamic view of a project affords building up a new triangle for any instantiation and version. The changes from one instantiation to another can be well documented in this fashion. (Frohberg 2009)

Table gives an overview of the core factors and scale used by Frohberg.

		Scale				
Factor	Issue	1	2	3	4	5
Context: Where and when?	Relevancy of environment and learning issue	independent context	formalized context	x	physical context	socializing context
Tools: Wherewith?	Pedagogic role of tools	content delivery	interaction for motivation & control	guided reflection	reflective data collection	content construction
Control: How?	Tightness of control	full teacher control	mainly teacher control	scaffold	mainly learner control	full learner control
Communication: With whom?	Social setting	isolated learners	lose couples	tight couples	communication within group	cooperation
Subject: Who?	Previous knowledge	novice	little previous knowledge	good previous knowledge	much previous knowledge	expert
Object(ive): What?	Level	know	comprehend	apply	analyze	synthesize and evaluate

(Frohberg 2009)

Context

Frohberg's classification consists of four categories: independent, formalized, physical and socializing context. A project is categorized as "independent" if the current environment of the learner has no relationship to his or her current issue of learning. The context of a learner in a project classified as

“formalized” is usually the classroom or a classroom-like setting. If a project is classified as “physical context,” the place of being is relevant for the learning issue. In a “socializing context” learners share sustainable, interpersonal relationships including current or past situations, emotions, friends, learning history, etc. (Frohberg 2009)

Forsberg found most projects in physical context, and almost as many in independent and formalized context, but hardly any in socializing context. (Frohberg 2009)

Tools

“On content delivery “there is readily prepared content to be delivered to the learner. On the contrary on “content construction” the learners are working actively with tools and are producing learning content on their own. On ‘interaction (with tools) for (the purpose of) motivation and control’ content is still delivered, but some of it may be consumed more than just passively; for example, there can be a multiple-choice-quiz or content that needs to be searched from somewhere in the environment. On “guided reflection” the tool delivers less content to the user. Instead, it focuses on the given environment, e.g., the surrounding, and gives the learner situated tasks on which to reflect. On “reflective data collection” the learners have to explore an environment on their own. The tool is used as an instrument for measurement and data collection. (Frohberg 2009)

The large majority of the projects are rated with a value of only 1 or 2. The tool support of most projects is not pedagogically ambitious; a strong minority provides tools that aim at realizing higher pedagogical goals. (Frohberg 2009)

Control

Control reflects on the responsibility of the teacher or the learner for setting the right target and a meaningful process of learning. Control can range from tight teacher control to full learner control. The optimal level of control may be in between both extremes: learners need sufficient scaffolding to be oriented, but without being dominated. (Frohberg 2009)

Most educational settings in Mobile Learning prefer a rather tight guidance by a teacher with little free space for the learners. (Frohberg 2009)

Communication

The scale of communication describes the degree of communication and interaction between different learners in a learning scenario. The isolated learner does not interact with anything other than the learning material and the given tools and she is responsible for reaching the learning goals on her own. In loosely coupled pairs students use the same device or consume the same learning material, but the learning scenario forces no additional communication or interaction between the pairs. If the learners are closely paired, they also use the same device or the same learning material, but the learning scenario gives tasks which are aimed at enhancing the communication or the interaction, for example, solving a specific exercise. They can discuss with each other and help their team mates. Level four connects several closely paired teams, and forces the communication or the interaction between them to improve mutual reflection. The last level of the continuum is where the learning scenario forces the collaboration between the teams to fulfill the learning goal. (Frohberg 2009)

From 102 projects, 49 projects have isolated learners and 29 have learners in loose pairs. Only 24 projects enhanced the learning scenario with advanced communication and interaction. (Frohberg 2009)

Subject and objective

The subjects in a learning process are the learners from novices (young pupils, fresh students or first time visitors in museums) to experts. Mobile Learning should not limit itself to create knowledge and comprehension, but rather support learners in applying, analyzing, synthesizing and evaluating their knowledge.

Only 7 projects address learners with good previous knowledge. There are no projects with learners that have much previous knowledge or can be called experts. There are only 18 projects that provide any higher level of learning than factual knowledge or comprehension. (Frohberg 2009)

2.5. Task model and my mobile experiments

I mirrored two of my mobile learning experiments towards Frohberg's core factors and scales.

2.5.1. Revision of probability calculation with SMS-messages and MLE

Context: independent context

There is no specific cognitive advantage for the learner to learn mathematics with my MLE in a café. He could as well do it at classroom or at home. The context of being is independent from the context of learning.

Tools: interaction for motivation and control

Content is consumed more than passively, because there were questions to students to answer. There was also a playful approach to learning with hope of raised motivation.

Control: scaffold

If you answer was wrong or you don't know how to start the task; you got tips one by one. Learners need sufficient scaffolding to be oriented, but without being dominated. Learners are not homogenous, and each individual may need a different level of scaffolding.

Communication: tight couples or isolated learners

Some of students helped each other, because they were used to it on ordinary math lessons. Some of students felt competition (or because they want to simulate test situation where no communication is allowed) important aspect and doesn't communicate with other students.

Subject: good previous knowledge

Experiment was at the end of the course, so they have studied probability quite a lot. Of course they were not mathematicians, but not totally novices.

Object: Comprehend and apply

Tasks were real problems, where only knowing formulas are not enough. You must comprehend and apply to get them done.

2.5.2. Biology exam in the woods with MLE-Moodle

Context: physical context

The place of being is relevant for the learning issue. Tasks of exam were bound to different places in the woods.

Tools: guided reflection

Content is consumed more than passively, because there were exam questions to students to answer and students have to reflect about the environment to precede the tasks.

Control: mainly teacher control

Exam situations are always controlled by teacher even if this exam is very different from ordinary exams.

Communication: tight couples

Exam was done in the groups and students can negotiate with each other inside the group.

Subject: good previous knowledge

Experiment was at the end of the course, so they have studied biology quite a lot. Of course they were not biologist, but not totally novices.

Object: Comprehend and apply

Tasks were problems in real environment, where students must comprehend and apply information learned from their biology book.

References

Sharples 2002

Mike Sharples, Dan Corlett and Oliver Westmancott , The Design and Implementation of a Mobile Learning Resource, UK Springer-Verlag London Ltd, Personal and Ubiquitous Computing (2002)

Sharples 2007

Mike Sharples, Josie Taylor, Giasemi Vavoula
A Theory of Learning for the Mobile Age
The Sage handbook of e-learning research

Taylor 2006

Taylor J., Sharples M., Malley C. O', Vavoula G. & Waycott J. (2006) Towards a task model for mobile learning: a dialectical approach. *International Journal of Learning Technology* **2**, 138–158.

Vavoula 2005

Vavoula, G., (2005) A Study of Mobile Learning Practices, Internal Report, Deliverable 4.4 for the MOBIlearn project (IST-2001-37440)

Pask 1976

Pask AGS. Conversation Theory: Applications in Education and Epistemology. Elsevier, Amsterdam 1976

Frohberg 2009

Mobile Learning projects – a critical analysis of the state of the art
D. Frohberg, C. Göth & G. Schwabe
Blackwell Publishing Ltd Journal of Computer Assisted Learning (2009), **25**, 307–331

ITU 2010

<http://www.itu.int/ITU-D/ict/material/FactsFigures2010.pdf>

3. Design-science

“We build an artifact to perform a specific task. The basic question is, does it work? Building an artifact demonstrates feasibility. These artefacts then become the object of study. We build constructs, models, methods, and instantiations. Each is a technology that, once built, must be evaluated scientifically” (Marc & Smith 1995)

“The mission of design science is to develop knowledge for the design and realization of, i.e. to solve construction problems, or to be used in the improvement of the performance of existing entities, i.e. to solve improvement problems” (van Aken 2004)

Traditionally scientific research (basic research) tries to depict and explain the existing world: What the world is really like? Design science as applied research, for one, attempts to change the world by developing various practically useful artifacts as its research results. In design science relevant question is “how the world ought to be?”

In design science can be asked, is it possible to build some innovation (construction problem), how useful the innovation is or is it possible make existing construction better (improvement problem). (van Aken 2004)

Design science has been used as research method in Computer Science and Information Systems for decades. Right from the beginning computer scientists have developed new architectures for computers, new programming languages, new compilers, new algorithms, new data and file structures, new data models, new database management systems, and so on (Iivari 2007). Design science has also been used in many other fields like architecture, engineering, education, psychology and arts (Hevner 2010).

Design science comprises of two basic activities, build and evaluate. Building is a process of constructing an artifact or innovation for a specific aim. Evaluation is a process of determining how well the artifact performs. The artifact should be evaluated based on value or utility to users. (Järvinen 2004, Hevner 2004, Marc & Smith 1995)

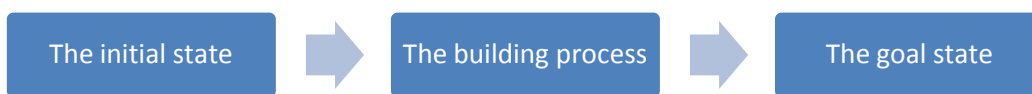
3.1 The building process

According to March and Smith (1995) design science research outputs are of four types, constructs, models, methods, and instantiations. *Constructs* or concepts form the vocabulary or language of a domain. A *model* is a set of propositions or statements expressing relationships among constructs. A *method* is a set of steps (an algorithm or guideline) used to perform a task. An *instantiation* is the realization of an artefact in its environment.

New constructs, models and methods have traditionally been wanted research outputs. In design science also the realization of artefact or innovation is included to research outputs. (Järvinen 2000)

According Järvinen (2000) constructs means terms, with which we describe good and poor aspects of *the initial state* and *the goal state* in the future. Constructs comes to use when we make description of these states. Description of the initial state makes a model of the initial state. Description of the goal state is a model of the situation, in which we want things to be, when we have constructed our artefact (Figure 1). The building process includes the method, which makes a transform form the initial state to the goal state. March & Smith write, "Instantiations operationalize constructs, models, and methods. However, an instantiation may actually precede the complete articulation of its underlying constructs, models and methods. Instantiations demonstrate the feasibility and effectiveness of the models and methods they contain".

(March & Smith 1995, Järvinen 2000, Järvinen 2004)



The purpose of the construction process is to obtain a movement from the initial state to the goal state. The goal state can be known or unknown. If it is known, the task of researcher as builder is to try implement the desired change from initial state to the goal state. If the goal state is unknown, we can firstly specify the goal state and then try to implement actions to get that state or we can in parallel realize both goal-seeking and implementation. Instead of realizing our own artifact, we can also purchase a ready-made artifact, if such one exists in competitive price. The hopes of builder will not always come true. The final state may differ from the goal state.(Järvinen 2004)

3.1.1 The specification process

The specification process produces description of the goal state. When researcher is making innovation on his own, he can make description of the goal state easily, because there are no many interest groups with different goals, as there is when we talk about routine design work in business or industry. Researcher must to do thorough literature research, so that he can be sure that his innovation is first in its class or that his development work makes a significant improvement to the previous innovation. (Järvinen 2000)

3.1.2. The implementation process

In this section the search question is: Having the specific initial and goal states and particular resources, how could we build an artifact satisfying the given specifications? To solve this "how" problem we need some theoretical or/and empirical *concepts and ideas*. In the study report technological, theoretic, informational and organizational ideas utilized in building the artifact must be described. (Järvinen)

Another important topic to be included into report is *design alternatives*. In the implementation process researcher can use at least two different heuristics: problem reduction and state-transition. *In the problem reduction heuristic* a problem is divided into sub-problems, and the latter again into sub-sub-problems, etc. until the solvable sub-... problem is found. *The state transition heuristics* means that the initial state is transformed to the goal state in the sequence of transitions. A researcher can report every transition from state n to state $n+1$. (Järvinen)

3.1.3 Purchasing a ready-made artifact or making it from existing parts

If the same or similar system already exists, it is not reasonable to reinvent a bicycle. The merit of the purchasing process as a scientific effort can be small (Järvinen).

I included ready-made products Opit-Binder and MLE-Moodle to my research as design alternatives.

3.1.4 Parallel specification and implementation processes

People have difficulties to imagine such that did not exist so the definition of the goal state is complex. Process can be easier, if some sketches of the goal state are experimented and at the same moment also realized by making prototypes. (Järvinen)

3.2 Evaluation of innovation

Cleven (2009) gives two definitions for evaluation.

“Evaluation is the process of determining the worth, merit, or significance of entities; and evaluations are the outcome of that process. Evaluation may be external or internal, or a mix of these; and it may quantitative or qualitative, or a mix of these. It is strongly although not always sharply distinct from explanation.”

“Objective and systematic collection of information about a program, project, or instructional material for its improvement. (More recently in literature, evaluation is being defined as the systematic investigation of the worth or merit of an object; e.g., a program, project, or instructional material.)”

In order to actually achieve utility when developing an artifact two requirements must be fulfilled: relevance and rigor. Relevance is achieved when the artifact actually addresses a real business (in this case educational) need. Rigor is assured by appropriately applying the existing body of knowledge, i.e. theoretical foundations and methodologies. (Cleven 2009)

Approach to evaluation can be quantitative or qualitative. In the case of a quantitative evaluation characteristics of the evaluation object are assessed on a numerical basis. In the case of qualitative evaluation characteristics of the evaluation object are appraised on a value basis, and “emphasizes the description and understanding of the situation behind the factors”. It is possible to evaluate both ways – quantitatively and qualitatively – and that a mixed method approach may provide even deeper insights into the quality of the evaluation object.

Research in the build activity should be judged based on value or utility to a community of users. March and Smith (1995) indicate that "building the first of virtually any set of constructs, model, method, or instantiation is deemed to be research, provided the artifact has utility for an important task. The research

contribution lies in the novelty of the artifact and in the persuasiveness of the claims that it is effective. Actual performance evaluation is not required at this stage". According to Järvinen (2000, 2004) also in this case artefact should be evaluated. If the artefact in a certain form already exists, March and Smith (1995) indicate that "The significance of research that builds subsequent constructs, models, methods, and instantiations addressing the same task is judged based on "significant improvement," e.g., more comprehensive, better performance".

3.3. Guidelines for design science research

Hevner et al. (2004) published seven guidelines for design science in information systems research (Table 1).

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

3.2.1. Guideline 1: Design as an Artifact

The result of design-science research in IS is, by definition, a purposeful IT artifact created to address an important organizational problem. It must be described effectively, enabling its implementation and application in an appropriate domain. (Hevner 2004)

Artifacts constructed in design science research are rarely full-grown information systems that are used in practice. Instead, artifacts are innovations that define the ideas, practices, technical capabilities, and products through which the analysis, design, implementation, and use of information systems can be effectively and efficiently accomplished. (Hevner 2004)

Artifact instantiation demonstrates feasibility both of the design process and of the designed product. (Hevner 2004)

3.2.2. Guideline 2: Problem Relevance

The objective of research in information systems is to gain knowledge and understanding that enable the development and implementation of technology-based solutions to heretofore unsolved and important problems. Design science moves to this goal through the construction of innovative artifacts aimed at changing the phenomena that occur. (Hevner 2004)

A problem can be defined as the differences between a goal state and the current state of a system. Problem solving can be defined as a search process using actions to reduce or eliminate the differences. (Hevner 2004)

3.2.3. Guideline 3: Design Evaluation

The utility, quality, and efficacy of an artifact must be thoroughly demonstrated via well execute evaluation methods. Evaluation is an imperative component of the research process. The environment establishes the requirements upon which the evaluation of the artifact is based. Evaluation includes the integration of the artifact within the technical infrastructure of the environment. (Hevner 2004)

IT artifacts can be evaluated in terms of functionality, completeness, consistency, accuracy, performance, reliability, usability, fit with the organization, and other relevant quality attributes. (Hevner 2004)

Design evaluation methods can be for example case study, field study, simulation or functional (black box) testing. (Hevner 2004)

3.2.4. Guideline 4: Research Contributions

Most often, the contribution of design-science research is the artifact itself. The artifact must enable the solution of heretofore unsolved problems. It may extend the knowledge base or apply existing knowledge in new and innovative ways. (Hevner 2004)

3.2.5. Guideline 5: Research Rigor

Design-science research requires the application of rigorous methods in both the construction and evaluation of the designed artifact. (Hevner 2004)

With respect to the construction activity, rigor must be assessed with respect to the applicability and generalisability of the artifact. (Hevner 2004)

Designed artifacts are often components of a human-machine problem-solving system. For such artifacts, knowledge of behavioral theories and empirical work are necessary to construct and evaluate such artifacts. Constructs, models, methods, and instantiations must be exercised within appropriate environments. (Hevner 2004)

3.2.6. Guideline 6: Design as a Search Process

Design is essentially a search process to discover an effective solution to a problem. Problem solving can be viewed as utilizing available means to reach desired ends while satisfying laws existing in the environment. (Hevner 2004)

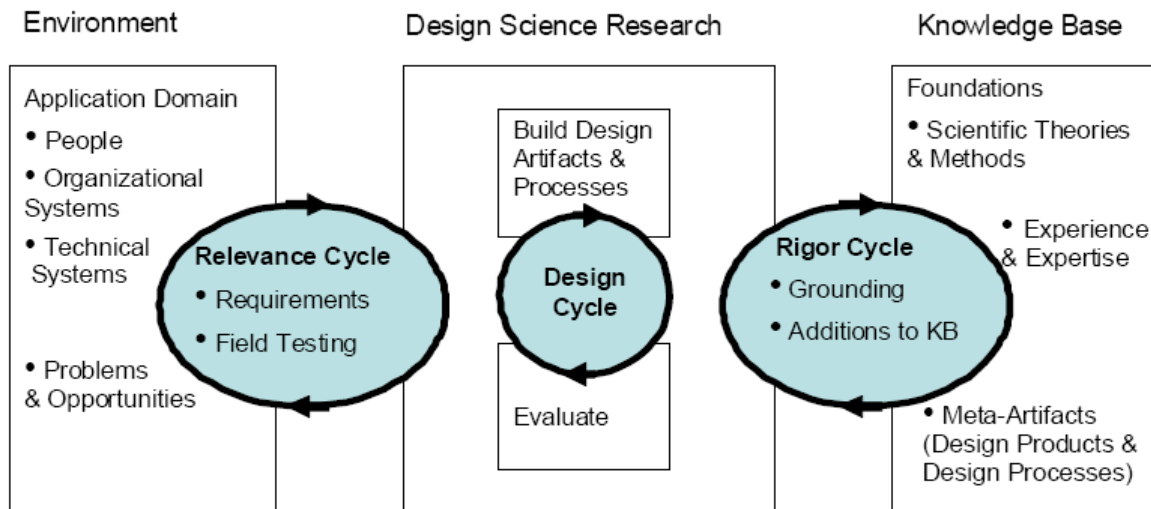
Design-science research often simplifies a problem by explicitly representing only a subset of the relevant means, ends, and laws or by decomposing a problem into simpler sub problems. Such simplifications and decompositions may not be realistic enough to have a significant impact on practice but may represent a starting point. Progress is made iteratively as the scope of the design problem is expanded. As means, ends, and laws are refined and made more realistic, the design artifact becomes more relevant and valuable. (Hevner 2004)

3.2.7. Guideline 7: Communication of Research

Design-science research must be presented both to technology-oriented as well as management oriented audiences. Technology-oriented audiences need sufficient detail to enable the described artifact to be implemented and used within an appropriate organizational context. This enables practitioners to take advantage of the benefits offered by the artifact and it enables researchers to build a cumulative knowledge base for further extension and evaluation. It is also important for such audiences to understand the processes by which the artifact was constructed and evaluated. This establishes repeatability of the research project and builds the knowledge base for further research extensions by design-science researchers in IS. (Hevner 2004)

Management-oriented audiences need sufficient detail to determine if the organizational resources should be committed to constructing or purchasing and using the artifact within their specific organizational context. (Hevner 2004)

3.3. A Three Cycle View of Design Science Research



Hevner posits that relevance, design and rigor cycles must be present and clearly identifiable in a design science research project. (Hevner 2007)

The *Relevance Cycle* connects the contextual environment of the research project with the design science activities. An application domain consists of the people, organizational and technical systems that interact to work toward a goal. Design science research often begins by identifying and representing potentials and problems in an actual application context. Iivari (2007) points out that some design science research is about potentiality; the identification of new opportunities to improve practice before any problem is recognized. (Hevner 2007)

The relevance cycle initiates design science research with an application context that not only provides the requirements for the research (e.g., the opportunity/problem to be addressed) as inputs but also defines acceptance criteria for the ultimate evaluation of the research results. Does the design artifact improve the environment? How can this improvement be measured? The output from the design science research must be returned into the environment for study and evaluation in the application context. The field study of the artifact can be carried out by means of appropriate technology transfer methods such as action research. The results of the field testing will determine whether additional iterations of the relevance cycle are needed in this design science research project. (Hevner 2007)

The *Rigor Cycle* bridges the design science activities with the knowledge base of scientific foundations, the existing artifacts and processes found in the application domain, experience, and expertise that informs the research project. The experiences and expertise define the state-of-the-art in the application domain of the research. The rigor cycle provides past knowledge to the research project to ensure its innovation. It is contingent on the researchers to thoroughly research and reference the knowledge base in order to guarantee that the designs produced are research contributions and not routine designs based upon the application of well-known processes. (Hevner 2007)

Additions to the knowledge base as results of design research will include any additions or extensions to the original theories and methods made during the research, the new artifacts (design products and

processes), and all experiences gained from performing the iterative design cycles and field testing the artifact in the application environment. (Hevner 2010)

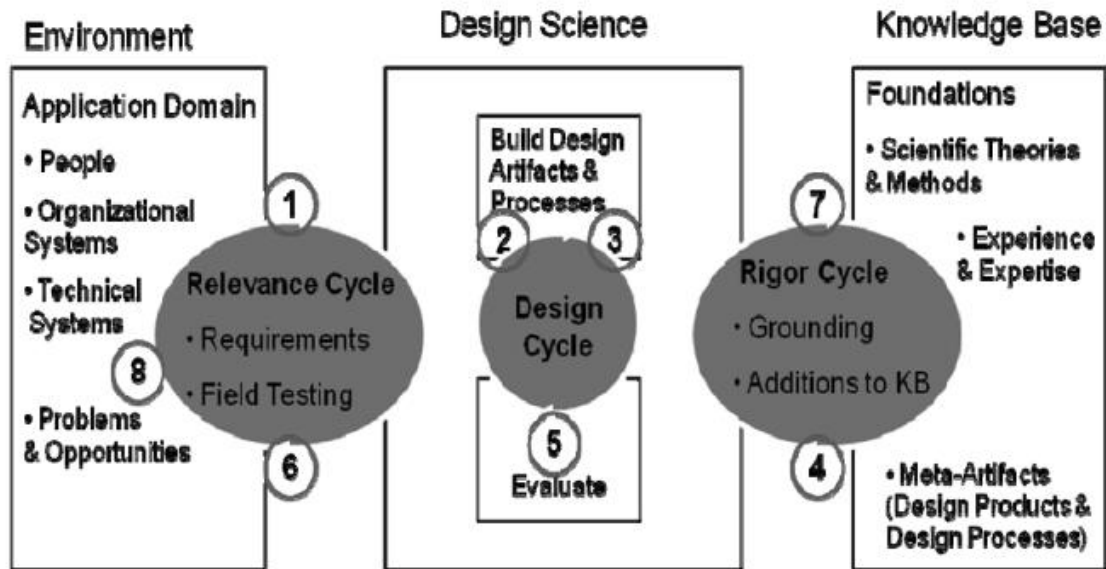
The central *Design Cycle* iterates between the core activities of building and evaluating the design artifacts and processes of the research. Simon (1996) describes the nature of this cycle as generating design alternatives and evaluating the alternatives against requirements until a satisfactory design is achieved. The requirements are input from the relevance cycle and the design and evaluation theories and methods are drawn from the rigor cycle. However, the design cycle is where the hard work of design science research is done. Hevner believes that it is important to understand the dependencies of the design cycle on the other two cycles while appreciating its relative independence during the actual execution of the research.(Hevner 2007)

During the performance of the design cycle a balance must be maintained between the efforts spent in constructing and evaluating the evolving design artifact. Both activities must be convincingly based on relevance and rigor. Iivari (2007) states, "The essence of Information Systems as design science lies in the scientific evaluation of artifacts." Artifacts must be rigorously and in detail tested in laboratory before releasing them into field testing along the relevance cycle. This calls for multiple iterations of the design cycle in design science research before contributions are output into the relevance cycle and the rigor cycle. (Hevner 2010)

The seven guidelines (Hevner 2004) have been largely accepted as integral to top quality design science research. Hevner (2010) also presents more specific checklist of questions to evaluate a design research project:

1. What is the research question (design requirements)?
2. What is the artifact? How is the artifact represented?
3. What design processes (search heuristics) will be used to build the artifact?
4. How are the artifact and the design processes grounded by the knowledge base? What, if any, theories support the artifact design and the design process?
5. What evaluations are performed during the internal design cycles? What design improvements are identified during each design cycle?
6. How is the artifact introduced into the application environment and how is it field tested? What metrics are used to demonstrate artifact utility and improvement over previous artifacts?
7. What new knowledge is added to the knowledge base and in what form (e.g., peer-reviewed literature, meta-artifacts, new theory, new method)?
8. Has the research question been satisfactorily addressed?

To demonstrate the relationship of these questions with the three research cycles discussed in the previous section, Figure 5 maps the eight questions to the appropriate research cycle. (Hevner 2010)



I shall now apply Hevner's checklist to my research .

1.

Are there in the near future any possibilities to wide use of mobile learning in basic education and upper secondary schools in Finland? We had lack of mobile infrastructure in school, so this technological problem must solve first. We need introduce pedagogy of mobile learning to ordinary schools, but also pure technology is needed. We shall use student's own mobile phones, because schools don't have extra money to buy to all students' smart phones or PDAs. Basic mobile phone with SMS- and MMS- support is not very intelligent device itself, but if we can combined it with web-server technology, it can be used as interactive and collaborative learning device. In year 2004, that there was not available any open source or commercial mobile learning environment, so I must build one if possible. **Is it possible to build a cost-efficient and stable working mobile learning/information environment MLE with SMS-messages (MMS-messages) as mediating technology?**

2.

My design science artifacts are the mobile learning server and the mobile learning environment. When I started to implement these artifacts, my aim was that these must be constructed with low cost and that use of them must also be cheap for school and pupils. Wide use of mobile learning is not possible, if costs are great.

Mobile learning server (MLS) consists of two parts, server core platform (SCP) and mobile application platform (MAP). MLS makes possible to rapidly and easily to construct many kinds of applications for mobile learning which together constitutes a mobile learning environment (MLE). I have published specifications and exact building instructions of MLS and MLE in my blog vps.virtuaalikoulu.org/mle. With these instructions schools teacher of information technology or it-support person can build own server and teachers can begin to use MLE and develop own models of using mobile learning.

3.

Both the problem reduction heuristic and the state transition heuristics were used.

Problem was divided into sub-problems: constructing of MLE and constructing of MLS, which has own sub – problems constructing of SCP and constructing of MAP.

SCP was first a basic Debian Linux server, which was later made ready for production use by solving how to organize backup and security of the system. MAP supports first only SMS messages and later also MMS messages. MLE was first supporting only learning use and SMS-messages, but was also widened to information and counseling use and MMS-messages.

Two design alternatives were also introduced when these come to markets: commercial Opit Binder and open source product MLE-Moodle.

4.

Past and ongoing research of mobile learning was checked from the literature and by participating to the conferences. I explored also to some extent the theory of mobile learning and different learning theories from pedagogy. I published annually my research outcomes in scientific conferences, so I can be sure that my artefacts were new innovations, not only routine design. After I started my research, also similar projects with same tools has raised from professional university researchers showing that my ideas were not trivial.

5. and 6.

I made some internal beta testing and real school life field testing after every building cycle. The survey was made for students participating to these mobile learning experiments. I analyzed results carefully with statistical methods.

During cycles some design improvements was found and implemented on the next cycle like

- SMS is a good start, but MMS is needed if I really want to teach larger entities like a whole math lesson with theory and exercises.
- I must solve how to organize backup and security of the system. Mobile learning systems contain important information in the form of student data, course and announcement material. Possible system crashes can cause the loss of this information. Spam and viruses are reality also in the mobile world. Also, the hackers should be kept outside the system. Municipalities and the schools IT support does not allow any systems in which these issues are not taken care of.
- What is the relation between mobile learning vs. web-based learning environments like Moodle, which are coming to mainstream tools in Finnish schools?

7.

The main contribution to the knowledge base is the artifacts itself: the mobile learning server MLS and the mobile learning environment MLE. Results from the field tests are reported on the peer-reviewed conferences.

8.

Is it possible to build a cost-efficient and stable working mobile learning/information environment MLE with SMS-messages (MMS-messages) as mediating technology?

MLE was build and it was found well working and cost-efficient construction. The research question has been satisfactorily addressed.

Are there in the near future any possibilities to wide use of mobile learning in basic education and upper secondary schools in Finland?

Maybe there is. My MLE is not anymore the technological help to this question. The future is not in mobile messaging technologies, but in mobile data connections.

The future depends about these factors

- Are web based learning environments like Moodle coming to wider use?
- Is there possibility to use them with mobile devices via light user interface like MLE-Moodle?
- Are young people's fixed-rate mobile data connections becoming more common or is the price of mobile devices like tablet pc's going so low that Finnish municipals can buy them large amounts?

3.4. The Ethics of Design Science

Design science research in itself implies an ethical change from describing and explaining of the existing world to shaping it. The ethics of research concern the responsibility of a scientist for the consequences of his research and its results. Even though it may be questionable whether any research can be value-free, it is absolutely clear that design science research cannot be. Consequently, the basic values of research should be expressed as explicitly as possible. (Iivari 2007)

There are three potential roles for Information Systems as an applied discipline:

1) Means-end oriented

The scientist aims at providing means knowledge for achieving given ends (goals), without questioning the legitimacy of those ends.

2) Interpretive

The aim of an interpretivist scientist is to enrich people's understanding of their action, how social order is produced and reproduced. The goals (ends) of action are often not so clear, and one should also focus on unintended consequences.

3) Critical

A critical scientist sees that research has a critical imperative: the identification and removal of domination and ideological practice. Goals (ends) can be subjected to critical analysis. (Iivari 2007)

Much design science research is naturally means-end oriented. This concerns especially constructive research involved with the building of artifacts. But constructive research can also be critical. Evaluation studies can be means-end oriented, interpretive and/or critical. A means-end oriented evaluation is only

interested in how effectively the artifact helps achieve the given goals or ends. An interpretive piece of evaluation research may attempt to achieve a rich understanding of how an IT artifact is really appropriated and used and what its effects are, without confining the focus on the given ends of its initial construction. A critical study is interested in how an IT artifact enforces or removes unjustified domination or ideological practices. (Iivari 2007)

One can also question the values of IS research, i.e. whose values and what values dominate it, emphasizing that research may openly or latently serve the interests of particular dominant groups. The interests served may be those of the host organization as perceived by its top management, those of IS users, those of IS professionals or potentially those of other stakeholder groups in society. (Iivari 2007)

Some ethical points to my research and mobile learning in general:

1. With mobile technology control and management of learning can be distributed. In a classroom the control over learning remains firmly with the teacher, but for mobile learning it may be distributed across learners, guides, teachers, technologies and resources in the world such as books, buildings, plants and animals. (Sharples 2005)

2. Learning needs are quite well satisfied in western countries, but in developing countries there is huge need of better education. Mobile learning can be one answer in point of view of learning technology. In Africa mobile infrastructure is widely spread than traditional fixed communication infrastructure and price of mobile clients are lower than computers (Barker 2005).

My artefacts can be well used in developing countries because they are not too high-tech and use of them can be cheap.

3. ICT has integrated into schools with an aim of improving teaching and learning in different subjects and also with an aim of increasing motivation for both students and teachers. Use of technology in schools has believed to have a positive impact on the schools' learning environments by

i) creating more dynamic interaction between students and teachers,

ii) increasing team work in problem-solving activities,

iii) stimulating creativity in both students and teachers, and

iv) helping students to control and monitor their own learning. (OECD 2005)

We can believe that use of mobile technology has same kind of positive impacts.

4. Cotton has collected the main results in nearly 60 publications from the 1980s and early 1990s: Computer aided instruction (CAI) produced better achievement effects than traditional teaching without computers. The use of computers also led to positive changes in attitudes towards school and learning in general, as well as in motivation. Low achievers and handicapped students benefited more than higher-achieving students; young pupil's more than older ones; students with a weak socio-economic background more than students whose parents were wealthy and highly educated; boys more than girls. The positive effects were especially visible with retaining learned material and doing various routine tasks. (Sinko 1999)

Lehtinen et al. compiled 1998 information from about 200 studies in the area of effects of computer-supported collaborative learning. Where computers were formerly viewed as a tool for individualizing

instruction, they are now viewed as a tool for social interaction and collaborative activities. Many studies report positive learning effects with computer- supported collaborative learning. Collaborative learning produce wholly new kinds of processes for activities and learning which have not even been sought in traditional teaching and whose effects also cannot be directly compared with the outcomes of traditional instruction. (Sinko 1999)

We can believe that use of mobile technology has same kind of positive impacts to learning results.

5. In her meta-analysis, Bayraktar found 2002 that in science education in secondary and college level computers were more effective when used in simulation or tutorial modes. CAI was more effective when computers were used individually by students. She suggested that tutorial and simulation CAI programs could be used in science classrooms to enhance student learning and classrooms should have sufficient computers for students to work individually. Furthermore, the studies showed that CAI was more effective when used as a supplement to traditional instruction rather than as a substitute. Therefore, the use of ICT in conjunction with other teaching strategies could be more beneficial for student learning. Another important finding revealed that teacher-developed programs were more effective than commercial software programs. (Eng 2005)

Use of ICT in schools is quite low when we are talking another use than Internet search and word processing. One obstacle is that computers are not on hands all the time. Eng points out that CAI was more effective when computers were used individually by students.

How about if *every student* has *every lesson* an own mobile client, an own little computer, in use? Would this lead to frequent and integral use of computational technology in schools? Would this lead to better and covering electric learning material from publishers? Would this wide pedagogical arsenal of a teacher, more constructive and collaborative learning?

3.5. Ongoing discussion about design science

In the last few years design science research has gathered attention within the IS community. After the article published by Hevner, et al. appeared in 2004 in MIS Quarterly, this type of research paradigm became acceptable as an alternative to traditional behavioral research. In 2006 DESRIST (The International Conference on Design Science Research in Information Systems and Technology) was created as platform to publish and showcase design science research conducted within the community. The literature on design science has exploded in the last few years creating a lively discussion emphasizing the balance between rigor and relevance in research. How the quality of design science research should be judged? There is also inconsistency with regards to the terminology, the underlying philosophy and the strategy to follow when doing design science. (DESRIST 2010)

The Hevner et al. guidelines are largely accepted, but caution is also raised to apply them less mechanistically than at present. Some guidelines are seen to be less important at earlier stages of research. Caution is also urged not to expect single researches to fit all guidelines. (DESRIST 2010)

References

- Jarvinen, P. (2004) On Research Methods. Tiedekirjakauppa TAJU publisher, Helsinki, Finland
- March, S. and Smith, G. (1995). "Design and Natural Science Research on Information Technology." Decision Support Systems 15 (1995): 251 - 266.
- Van Aken J.E. (2004), Management research based on the paradigm of the design sciences: The quest for field-tested and grounded technological rules, *Journal of Management Studies* 41, No 2, 219-246.
- R. Winter, J.L. Zhao, and S. Aier (Eds.): DESRIST 2010 Springer-Verlag Berlin Heidelberg 2010
- Hevner, A., March, S., Park, J. and Ram, S. (2004). "Design Science in Information Systems Research." MIS Quarterly 28(1): 75-105.
- Hevner, A. R. 2007. A Three Cycle View of Design Science Research. *Scandinavian Journal of Information Systems*, 19(2): 87 - 92.
- Hevner, A; Chatterjee, S. 2010 Design research in Information Systems, Theory and Practise, Springer, Integrated Series in Information Systems Volume 22
- Iivari, J. 2007, "A Paradigmatic Analysis of Information Systems as a Design Science, *Scandinavian Journal of Information Systems*, 19(2).
- Barker A., Krull G., Mallinson B. (2005) A Proposed Theoretical Model for M-Learning Adoption in Developing Countries, URL: <http://www.mlearn.org.za/CD/papers/Barker.pdf>
- Eng E. (2005) The impact of ICT on learning: A review of research, *International Education Journal*, 2005, 6(5), 635-650 Shannon Research Press.
- Facer K. Faux F., McFarlane A. (2005) Challenges and Opportunities: Making Mobile Learning a Reality in Schools , URL: <http://www.mlearn.org.za/CD/papers/Facer.pdf>
- OECD (2005) Are Students Ready for a Technology-Rich World?, URL <http://www.pisa.oecd.org/dataoecd/28/4/35995145.pdf>
- Cleven, Gubler, Hüner, Design Alternatives for the Evaluation of Design Science Research Artifacts; DESRIST '09 Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology, 2009
- http://desrist2009.ist.psu.edu/Papers/desrist2009_submission_40.pdf

Sharples M. (2005) Towards a Theory of Mobile Learning , Mike Sharples, Josie Taylor, Giasemi Vavoula University of Birmingham, UK, The Open University, UK ,URL
<http://www.mlearn.org.za/CD/papers/Sharples-%20Theory%20of%20Mobile.pdf>

Sinko M., Lehtinen E. (1999) The Challenges of ICT in Finnish education , Atena kustannus, Juva

4. The first cycle

My starting points to building of artifact in year 2004 were two teacher's observations from lessons.

1. When pupils solve on the lesson mathematical exercises they natural way without teacher's guidance build two or three pupils groups. In these groups they help each others to start exercise and compare their results. We need a model, how to support this learning process with technology. It should be possible to use this way of social learning outside lessons and outside classrooms. Terminal devices should be available for all pupils and devices should not bind learning to specific place and time as ADSL-connection at pupil's home or school's it-class do.
2. When in the class there are 20-35 pupils, teaching and learning can't be very individualized. With interactive technology pupils can get individualized feedback. Interactive applications can be game like and with them can be also done some tests (multiplication tables, word tests). Pupils are used to mobile games and competitions, which television and radio programs use.

These observations are quite parallel with theory of mobile learning (learning as conversation).

Method would be add-on to traditional teaching in the class room, not substitution to this. There is no need for wide use of distance learning in basic education and upper secondary schools in Finland.

In 2004-2005 when this first cycle starts, SMS was natural choice for communication protocol of mobile learning environment. SMS was only protocol with which I can be sure that all phones of pupils support it and those pupils are familiar with it.

4.1. Building of the artifact

Web-server (HTTP-server) is the middle point of learning environment. Pupils can communicate with server with various mobile devices and teacher can administrate learning environment via server. I chose to server software LAMP software bundle so Linux, Apache, MySQL and PHP. PHP is a good programming language for project, because PHP: s syntax is mainly from C-language so it is familiar for many coders. PHP is designed for server side web programming and it is easy to learn to use if you have early programming experience. Syntax and semantics of PHP is rich, but not so complicated like for example in Pearl. In PHP there is many functions ready for use of databases.

Apache was natural choice for HTTP-server software, because it has 70 % of markets and for it was possible to get many modules like MySQL and PHP support (Netcraft 2005). For database system I chose MySQL instead of PostreSQL, because MySQL was much more widespread.

Important tool is also phpMyAdmin. phpMyAdmin is an tool written in PHP intended to handle the administration of MySQL over the WWW. It can perform various tasks such as creating, modifying or deleting databases, tables, fields or rows; executing SQL statements; or managing users and permissions. With phpMyAdmin it was possible to do many administrative operations of the learning environment

without you shall first code these operations with PHP. So it was possible to get environment to use in the field faster.

As Linux distro I used Debian, because Debian has almost automatic security support and easy installation of software packages.

Database was designed by using entity-relationship model. Entities are Schools, Courses, Groups, Teachers, Pupils and Messages. Teacher can have many Schools and Courses. Pupils can have many Schools, Courses and Groups. Group can be same in many Courses. In design was noticed that pupils can do two degrees in different schools and regional cooperation so this same service can be used in many municipalities.

When web-server and database was ready, I started to implement user interface and user administration. User types were teacher and pupil. In www-login user rights are checked by username and password. With session functions and variables it was able to ensure that while whole users session security and comfort of use are remained. In SMS-login user rights are checked from phone number where SMS-message was sent. Phone numbers and email addresses can be move easily to environment from schools student database via Excel-sheet and phpMyAdmin.

Next step in implementation was coding of sending of messages. User can both send and read messages via WWW page. Sender can also in WWW page define that message goes also as SMS message so that receiver gets it without delay to his or hers mobile phone. With GSM phone it is possible to sent message via system to another user so that receiver reads message from WWW page when she or he next time logins into system but also message can go forwards in the system immediately as SMS message. A message can be sent to one user or group of users. A group can be beforehand grounded and named or can be selected from the list of users.

So students can send messages to other students or group of students from mobile to mobile, from mobile to WWW and from WWW to mobile and from WWW to WWW. Students WWW user interface is of course possible to use via mobile Internet with GPRS, EDGE or 3G connection, but user interface is not specially optimized to small screens.

Lastly was implemented the interactive part of system, which is described in the later section.

One important part of system was now needed, a bidirectional (sends and receives SMS messages) SMS gateway (SMS server), which connects together HTTP and SMS data communication. It can be bought from service provider, but price was quite high.

So one starting point to the building of schools mobile infrastructure is schools own SMS server. With this server it is possible to send and receive SMS messages to and from mobile phones. A Linux server with GSM phone connected to it with serial cable is capable to serve as SMS server. I used old Pentium II level desktop computer as first server and the phone was old Nokia 6210, so there is no need for some expensive machine investments. This server can be located in schools own local area network LAN.

Server can use for example free Kannel software to send and receive messages (Kannel 2006). In Finland cost of message sending was in 2006 0,01 Euros per message for first 1000 messages in month (if all messages are used) and next messages 0,12 Euros per message, if using GSM subscriber connection with message package. If you bought this kind of service from service provider, costs will be at least 10 times (for first 1000 messages in the month).

If both WWW server and SMS server can be building to same server, we get compact mobile information and teaching unit in one single computer. If server is situated in schools own LAN, then environments WWW features are in the use only inside schools LAN and WLAN, but SMS features are available all over the world where there is GSM network. Best solution will be, if server is in the demilitarized zone of schools LAN, so also WWW features are available all over the world. In my school it was difficult to get in reasonable price and time this demilitarized zone from municipals network service provider.

4.2. Evaluation of the artifact

What advantages can be seen in this kind of messaging system? When a teacher wants to send an urgent SMS message to many pupils at the same time, it is much more convenient to do that via WWW form than by using teachers own phone. You don't have need to know receivers phone numbers, because numbers are included in the database of the environment. It was already clear in the year 2005, that there will be in the future need for this kind of system in the counseling of pupils. Pupils can choice in which format they do messaging. When they are home or at school they can use WWW and fixed Internet connection like ADSL connection, which are "free". When a pupil sends a SMS group message via environment with her or his phone, it makes for him or her only one SMS messages cost, because the environment does the forwarding of the message.

In this research made learning environment tested first time in the year 2005 in Lempäälä Senior Secondary School. Students were 17-18 years old and topic was revision of probability calculation and as a new subject numerical derivative. Only the interactive part of system was tested. Students in experiment were 33 and 11 of them use environment via SMS and rest of them via WWW, as they self will. Two of 11 SMS users use environment also via WWW.

Tasks were like this: "In the lottery allots 7 number from 1,2,...,39. How much is the probability to get none from right numbers? Give the answer with three digits precision." If you answer was wrong or you doesn't know how to start the task; you got tips one by one:

Tip one: "Row is a 7 element subset of the 39 element set. Order of numbers is not essential, only which number are in the right row. How much there is different rows?"

Tip two: "Number of rows is 39 over 7 so with calculator 39 NCR 7."

Tip three: "There is 32 pieces of wrong numbers. Fortunate cases are rows, in which there is all numbers from those numbers. How much there are those kind of rows?"

The last tip was the right answer:"The right answer: $(32 \text{ over } 7) / (39 \text{ over } 7) = (32 \text{ NCR } 7) / (39 \text{ NCR } 7) = 0.219.$ "

Some gaming function was created by giving points from the right answer and you get more points if you use less tips. Students have possibility to see results of this game in the real time on the WWW-page.

A survey was made for the students after they have used environment. First number in the table is answers of the all users and second number is answers of SMS users.

About 70 % of users found use of environment easy and nice. In the group of SMS users this percentage was less. Only 12 % of students feel that the environment was not useful for learning. In the group of SMS users this percentage was greater. It was natural result, that students feel that environment suited better to revision than to learn new subjects. Only 15 % of students feel that tips were not useful. Almost 60 % of

students feel that solving tasks with the environment was more interesting than with pen and paper. Reading of mathematical text in SMS format was not so big problem for students as you would think. Only 16 % of students (18 % of SMS-users) don't want to use the environment any more.

Use of the environment was / The environment was/ The environment	easy	nice	useful in point of view of learning	suited well to revision	suited well to learn new subjects
agree very strongly	48 % / 36 %	39 % / 27 %	12 % / 0 %	18 % / 9 %	6 % / 0 %
agree strongly	24 % / 27 %	30 % / 27 %	24 % / 27 %	52 % / 55 %	21 % / 0 %
agree slightly	12 % / 9 %	15 % / 9 %	52 % / 45 %	15 % / 18 %	21 % / 36 %
disagree strongly	9 % / 18 %	12 % / 27 %	6 % / 9 %	9 % / 0 %	45 % / 45 %
completely disagree	6 % / 9 %	3 % / 9 %	6 % / 18 %	6 % / 18 %	6 % / 18 %

	Tips were useful when I was doing exercises.	Solving tasks with environment was more interesting than with pen and paper.	Solving tasks with environment was more difficult than with pen and paper.	It was difficult to read mathematical text in SMS format.	I don't want to use this environment any more.
agree very strongly	31 % / 27 %	34 % / 18 %	0 % / 0 %	3 % / 0 %	13 % / 18 %
agree strongly	34 % / 36 %	25 % / 36 %	13 % / 18 %	16 % / 18 %	3 % / 0 %
agree slightly	19 % / 18 %	22 % / 27 %	31 % / 36 %	29 % / 36 %	13 % / 0 %
disagree strongly	9 % / 18 %	16 % / 9 %	44 % / 27 %	29 % / 27 %	26 % / 55 %
completely disagree	6 % / 0 %	3 % / 9 %	13 % / 18 %	23 % / 18 %	45 % / 27 %

Students give also overall evaluation to the system with scale 4-10 and the average was 7.85.

These results encouraged me to go forward with my research. There were first problems with Kannel SMS Gateway with messages over 160 signs. When message is over 160 signs, it sends in two different messages, but this doesn't work in every cases. There were also problems when Kannel Gateway received messages from students: I must restart phone connected to server about once in the day, because it jammed. Messages don't wasted, but there was a delay receiving them. I believed that results of survey would be better, if there were not these technical problems. In the next building and evaluation cycle these problems were solved.

Some comments from students:

Best in this system:

- tips and it was force to think tasks at least a little time
- result service and possibility to train from home, possibility to train like this in Internet would be a quite nice idea
- racing and it was nice to do tasks just for “to pass the time”(not usually so with math), because it was easy to reach these tasks
- it was same where you made exercises, you was not fixed to some place

Worst in this system:

- phone gets fast full of messages when tasks and tips comes in
- theory lesson consisting of two sms-messages is quite short
- technology was clumsy when I start to use it
- lack of mathematical symbols make it difficult to perceive tasks versus tasks in the books

How to improve system?

- Videos, photos
- MMS would be excellent
- bugs away, possibility to check tasks on the lesson afterwards, because after some tasks I felt uncertain
- I want to do tasks in the group
- possibility to give answers in different formats

5. The second cycle

5.1 Building of the artifact

In cycle two some bugs with Kannel SMS Gateway was fixed. This made system more reliable.

Besides learning use I wanted also research counseling and announcement use of mobile tools. In cycle two tools for this specific use were coded to system.

With MLS it is possible to use mass SMS as information channel to pupils. Messages can be sent from any PC connected to internet. Each teacher can have his/her own username to system. Messages can be sent to whole school or some individuals or group gathered beforehand.

I also implemented some interactive tools to the system. With SMS-blog students can send SMS-messages to the web-bage. With SMS-vote it is possible to vote with SMS-messages and results can be seen in the web-page. With SMS-menu it is possible to ask with SMS-message school food of the day. I found that these kinds of SMS-applications can be implemented very easily.

5.2 Evaluation of the artifact

This mass SMS –system has got many users from the teachers. It was also useful to sending personal usernames and passwords of schools information systems to pupils and their parents. For this kind of use of mobile devices there was a clear need in schools 2005-2006. Use of mass SMS-system was evaluated 2009 after four years of use. These results can be read in chapter 8.

SMS-blog application was tested by very innovative way. Group of students was in St. Petersburg in Russia with their teacher. Teacher wanted to have an assembly from Russia to our school in Finland. We called our students in the school to the great hall, where we can watch students on study trip by public webcam which was in the street of St. Petersburg. Students started to send SMS-messages to the SMS-blog. I showed with data projector two web-pages to the students in the great hall of our school. In the first page was a live webcam from St. Petersburg, where we can see our students on study trip. In the second page there was in real time SMS-messages sent by students in Russia. Application worked very well and we had lots of fun.

In this research made interactive learning environment for mathematics tested second time in the year 2006 in Lempäälä Senior Secondary School. Students were 17-18 years old and topic was again revision of probability calculation and as a new subject numerical derivative. Students in experiment were 40 and 26 of them use environment via SMS and rest of them via WWW, as they self will. Two of 26 SMS users use environment also via WWW.

A survey was made for the students after they have used environment. First number in the table is answers of the all users and second number is answers of SMS users.

Over 70 % of users found use of environment easy and nice, so this result was a little better than last year. In the group of SMS users this percentage was now better than for all users, which was an interesting turnaround from last year. System was now reliable than last year, which can be seen in this numbers.

Only 13 % of students feel that the environment was not useful for learning. In the group of SMS users this percentage was this time less. It was again a natural result, that students feel that environment suited better to revision than to learn new subjects. 23 % of students feel that tips were not useful. 56 % of students feel that solving tasks with the environment was more interesting than with pen and paper. Reading of mathematical text in SMS format was not so big problem for students as you would think. Only 11 % of students (8 % SMS-users) don't want to use the environment any more. Also these were better results than last time.

Use of the environment was / The environment was/ The environment	easy	nice	useful in point of view of learning	suited well to revision	suited well to learn new subjects
agree very strongly	48 % / 54 %	30 % / 31 %	13 % / 15 %	30 % / 38 %	8 % / 12 %
agree strongly	30 % / 27 %	43 % / 46 %	40 % / 46 %	40 % / 42 %	13 % / 19 %
agree slightly	8 % / 8 %	20 % / 15 %	35 % / 35 %	20 % / 15 %	58 % / 54 %
disagree strongly	8 % / 8 %	8 % / 8 %	8 % / 4 %	3 % / 0 %	15 % / 15 %
completely disagree	8 % / 4 %	0 % / 0 %	5 % / 0 %	8 % / 4 %	8 % / 0 %

	Tips were useful when I was doing exercises.	Solving tasks with environment was more interesting than with pen and paper.	Solving tasks with environment was more difficult than with pen and paper.	It was difficult to read mathematical text in SMS format.	I don't want to use this environment any more.
agree very strongly	18 % / 27 %	18 % / 23 %	5 % / 0 %	8 % / 4 %	3 % / 4 %
agree strongly	28 % / 35 %	38 % / 38 %	28 % / 19 %	8 % / 8 %	8 % / 4 %
agree slightly	33 % / 23 %	35 % / 35 %	20 % / 27 %	28 % / 19 %	15 % / 12 %
disagree strongly	18 % / 15 %	10 % / 4 %	40 % / 46 %	41 % / 58 %	26 % / 31 %
completely disagree	5 % / 0 %	0 % / 0 %	8 % / 8 %	15 % / 12 %	49 % / 50 %

The overall evaluation to the system was now 8.32, when it was last year 7.85.

6. Deeper evaluation after cycle one and two

My aim was, that evaluation part of design science research should done so well, that we get also general findings on mobile learning phenomena in basic education and upper secondary schools in Finland. That is why I made also deeper statistical analysis of answers of students 2005 and 2006.

Here are questions asked from students and short codes of these questions. Questions 1 – 18 are background questions and 19-30 measure students attitude to MLE. In background questions I measured student's attitude to mathematics, information technology and mobile technology. In questions 12 – 29 was used Likert scale : agree very strongly (1) - agree strongly (2) - agree slightly (3) - disagree strongly (4) - completely disagree (5).

Question	Code
1. Way to use MLE a) WWW b) SMS c) both, but more WWW d) both, but more SMS.	metodi
2. Gender	sukupuoli
3. Average of math courses of second year with scale 4 - 10	matikannumero
4. I have a computer.	tietokonekotona
5. I have a mobile phone.	kannykkamulla
6. How many minutes at average you use computer at home and at school in one day?	koneenkayttoaika
7. How many Euros at average is your phone bill in one month?	kannylasku
8. How often you change to a new phone a) once in the half year b) once in the year c) once in the two years d) less often than once in the two years?	kannyvai
9. I have ordered background images or ringtones to my phone more often than once.	soittoaania
10. I have been participated in televisions SMS-games more often than once.	tvpelit
11. I have sent SMS-messages to televisions SMS-chats more often than once.	sattitv
<i>Answer with scale agree very strongly - agree strongly - agree slightly - disagree strongly - completely disagree</i>	
12. In my opinion mathematics is interesting.	matikkakiinnostaa
13. In my opinion it is important to have mathematical knowhow.	matikkatarkeaa
14. In my opinion it is important to have knowhow in information technology.	atktarkeaa
15. In my opinion computers are interesting.	atkkiinnostavaa
16. When I work with a computer I feel myself confident.	atkvarmanaolo
17. In my opinion mobile devices are interesting.	mobiilitkiinnostaa

18. I can't be one day without my phone.	kannyero
19. It was easy to learn to use MLE.	setaeasylearn
20. It was easy to use MLE.	setaeasyuse
21. It was nice to use MLE.	setamukavaa
22. MLE was useful for learning.	setaoppimisuseful
23. MLE suited well to revision.	setakertaus
24. MLE suited well to learn new subjects.	setauusi
25. SMS-tips were helpful.	setavinkitok
26. It was more interesting to study via MLE than only with pen and paper.	setakiinnostava
27. It was more difficult to use MLE to solve tasks than use only pen and paper.	setavaikea
28. It was difficult to read mathematical text in SMS-format.	setalukuvaikaa
29. I don't want to use MLE anymore.	setaeikayttoon
30. I give grade _ to MLE.	setaarvosan

There were 73 students, 48 men and 25 women. All except one has a computer. All except one has a phone. They used computer in one day on average 114 minutes, but there was 18 students spending time with computer 3 hours or more. Mean of math marks (scale 4 – 10) was 7,6 with standard deviation 1,5.

Four of students changed a new phone once in the half year, 5 once in the year, 33 once in the two years and 31 less often than once in the two years. 50 students have ordered background images or ringtones more often than once, but only 5 have sent SMS-messages to televisions SMS-chats more often than once and only 3 have been participated in televisions SMS-games more often than once.

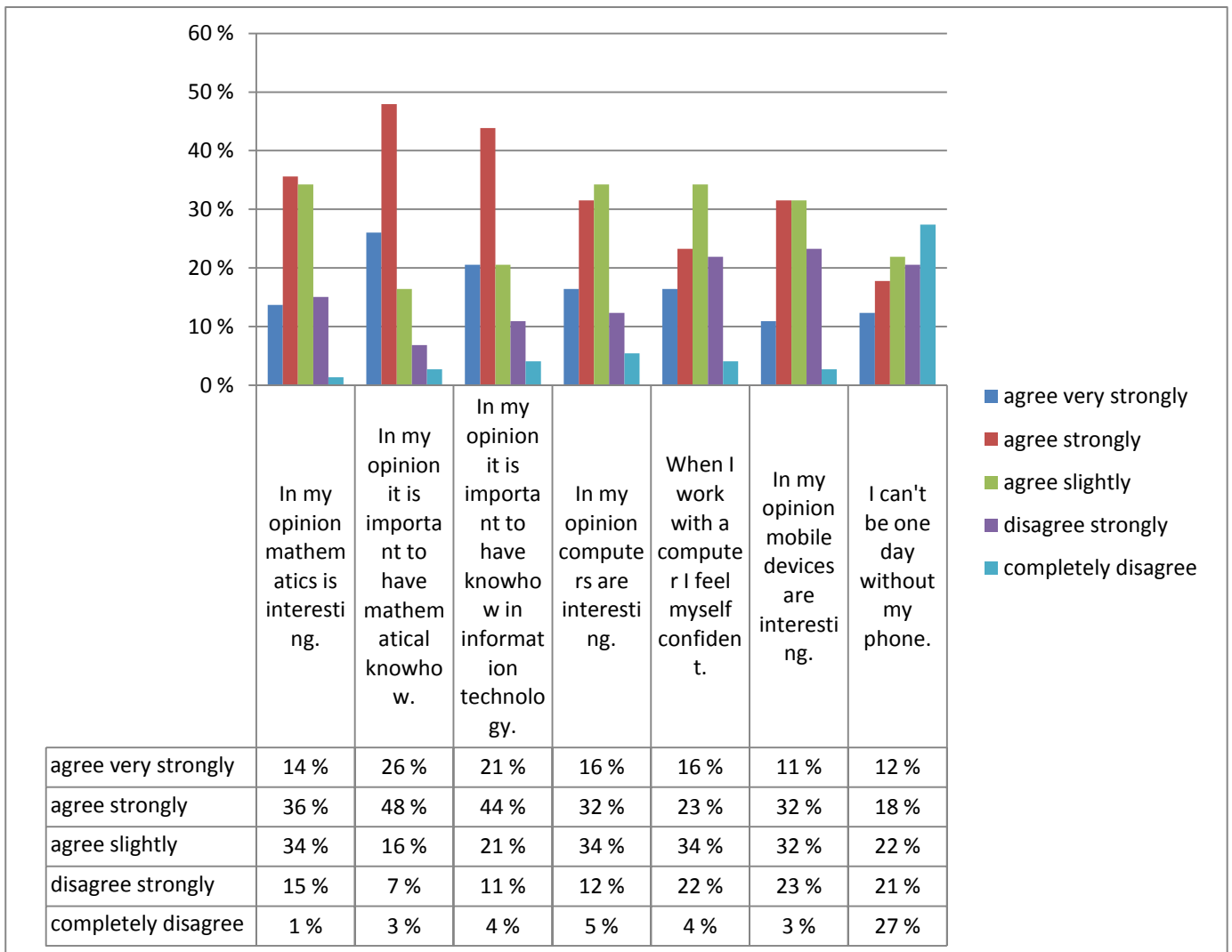


Chart 3.0

Student's attitude to mathematics, information technology and mobile technology can be seen in Chart 3.0. About 50 % of students feel mathematics interesting and over 70 % important. About 50 % of students feel computers interesting and 65 % feel that it is important to have knowhow in computers. Over 40 % feel mobile devices interesting and 30 % can't be one day without their phone.

They can freely choose their way to use MLE:

both, but more SMS 4
 both, but more WWW 4
 SMS 33
 WWW 32

6.1. Why students chose mobile way to use MLE? How SMS-users and WWW-users are different from their backgrounds?

I used means and Pearson's Chi-squared test to examine this.

<i>metodi</i>				
<i>soittoaania</i>	<i>SMS</i>	<i>WWW</i>	<i>Total</i>	<i>Count</i>
<i>No</i>	34.8	65.2	100	23
<i>Yes</i>	58.0	42.0	100	50
<i>Pearson's Chi-squared test</i>				
<i>X-squared = 3.3974, df = 1, p-value = 0.0653</i>				

Chart 3.1

<i>metodi</i>				
<i>sukupuoli</i>	<i>SMS</i>	<i>WWW</i>	<i>Total</i>	<i>Count</i>
<i>Man</i>	56.2	43.8	100	48
<i>Woman</i>	40.0	60.0	100	25
<i>Pearson's Chi-squared test</i>				
<i>X-squared = 1.7366, df = 1, p-value = 0.1876</i>				

Chart 3.2

In the light of these material students relation to his or her mobile phone (subscribing of background images and ringtones as indicator) may have some statistical correlation to choose of SMS-way. Gender does not affect to selection between SMS and WWW.

<i>Variable: atkkiinnostavaa</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	2.513514	1.145562	37	0
<i>WWW</i>	2.666667	1.014185	36	0
<i>Variable: atktarkeaa</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	2.297297	0.967955	37	0
<i>WWW</i>	2.388889	1.153325	36	0
<i>Variable: atkvarmanaolo</i>				

	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
SMS	2.567568	1.093936	37	0
WWW	2.916667	1.105183	36	0
<i>Variable: kannyero</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
SMS	3.378378	1.319751	37	0
WWW	3.250000	1.421770	36	0
<i>Variable: kannylasku</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
SMS	15.94595	8.343147	37	0
WWW	15.15152	8.728979	33	3
<i>Variable: koneenkayttoaika</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
SMS	139.86111	120.22292	36	1
WWW	82.14706	80.56096	34	2
<i>Variable: matikannumero</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
SMS	7.459459	1.538300	37	0
WWW	7.777778	1.456240	36	0
<i>Variable: matikkakiinnostaa</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
SMS	2.513514	0.9609492	37	0
WWW	2.555556	0.9693722	36	0
<i>Variable: matikkatarkeaa</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
SMS	2.027027	0.8328828	37	0
WWW	2.194444	1.1166134	36	0
<i>Variable: mobiilitkiinnostaa</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
SMS	2.675676	1.001500	37	0
WWW	2.861111	1.046157	36	0



Chart 3.3.

These background variables in chart 3.3, for example interest to mobiles or computers, do not have relation to selection between SMS- and WWW-way to use MLE. Maybe we can say, that mobile and computer orientated students doesn't choose mobile learning instead of traditional e-learning more than ordinary persons.

6.2. What is the influence of chosen user interface to the attitudes of students to the MLE?

I used means to examine this question.

<i>Variable: setaarvosan</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	8.135135		0.8551206	37 0
<i>WWW</i>	8.222222		0.8319035	36 0
<i>Variable: setaeasylearn</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	1.837838		1.280484	37 0
<i>WWW</i>	1.857143		1.263582	35 1
<i>Variable: setaeasyuse</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	1.972973		1.235729	37 0
<i>WWW</i>	2.000000		1.264911	36 0
<i>Variable: setaeikayttoon</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	4.054054		1.177237	37 0
<i>WWW</i>	4.000000		1.299038	33 3
<i>Variable: setakertaus</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	2.108108		1.100096	37 0
<i>WWW</i>	2.333333		1.121224	36 0

<i>Variable: setakiinnostava</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	2.297297	0.967955	37	0
<i>WWW</i>	2.342857	1.109925	35	1
<i>Variable: setalukuvaikeaa</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	3.594595	0.9562502	37	0
<i>WWW</i>	3.406250	1.2664244	32	4
<i>Variable: setamukavaa</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	2.189189	1.101460	37	0
<i>WWW</i>	1.916667	0.906327	36	0
<i>Variable: setaoppimisuseful</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	2.540541	0.9601677	37	0
<i>WWW</i>	2.611111	0.9936305	36	0
<i>Variable: setauusi</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	3.054054	0.970279	37	0
<i>WWW</i>	3.222222	1.045018	36	0
<i>Variable: setavaikea</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	3.432432	0.9291735	37	0
<i>WWW</i>	3.314286	1.1316679	35	1
<i>Variable: setavinkitok</i>				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
<i>SMS</i>	2.270270	1.044793	37	0
<i>WWW</i>	2.657143	1.258918	35	1

Chart 3.4.

Attitudes to the MLE are not different between SMS-users and WWW-users. Maybe the content and functionality are more important to the students than pure mobility?

6.3. Gender impact to certain variables

I used analysis of variance to examine gender impacts to some background questions.

Variable: atkkiinnostavaa				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
Man	2.333333	1.1547005	48	0
Woman	3.080000	0.7023769	25	0
Analysis of Variance Table				
Response: atkkiinnostavaa				
	<i>Df</i>	<i>Sum Sq</i>	<i>Mean Sq</i>	<i>F value</i> <i>Pr(>F)</i>
sukupuoli	1	9.165	9.165	8.7332 0.004237 **
Residuals	71	74.507	1.049	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				
Welch Two Sample t-test				
data: atkkiinnostavaa by sukupuoli				
$t = -3.4255$, $df = 69.153$, $p\text{-value} = 0.001036$				
alternative hypothesis: true difference in means is not equal to 0				
95 percent confidence interval:				
-1.1814887 -0.3118447				
sample estimates:				
	mean in group Man		mean in group Woman	
	2.333333	3.080000		

Chart 3.5.

Variable: atkvarmanaolo				
	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>NA</i>
Man	2.458333	1.129080	48	0
Woman	3.280000	0.842615	25	0

Analysis of Variance Table					
Response: atkvarmanaolo					
	Df	Sum Sq	Mean Sq	F value	Pr(>F)
sukupuoli	1	11.098	11.098	10.239	0.002056 **
Residuals	71	76.957	1.084		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Welch Two Sample t-test					
data: atkvarmanaolo by sukupuoli					
t = -3.5049, df = 62.131, p-value = 0.0008535					
alternative hypothesis: true difference in means is not equal to 0					
95 percent confidence interval:					
-1.2902718 -0.3530615					
sample estimates:					
mean in group Man mean in group Woman					
		2.458333	3.280000		

Chart 3.6.

Variable: kannyero				
	mean	sd	n	NA
Man	3.645833		1.391304	48 0
Woman	2.680000		1.069268	25 0
Analysis of Variance Table				
Response: kannyero				
	Df	Sum Sq	Mean Sq	F value Pr(>F)
sukupuoli	1	15.334	15.334	9.1939 0.003389 **
Residuals	71	118.419	1.668	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

Welch Two Sample t-test	
data: kannyero by sukupuoli	
t = 3.2923, df = 60.834, p-value = 0.001658	
alternative hypothesis: true difference in means is not equal to 0	
95 percent confidence interval:	
0.3791883 1.5524784	
sample estimates:	
mean in group Man mean in group Woman	
3.645833	2.680000

Chart 3.7.

Variable: koneenkayttoaika				
	mean	sd	n	NA
Mies	143.9556	110.16928	45	3
Nainen	54.0000	68.98067	25	0
Welch Two Sample t-test				
data: koneenkayttoaika by sukupuoli				
t = 4.194, df = 66.917, p-value = 8.239e-05				
alternative hypothesis: true difference in means is not equal to 0				
95 percent confidence interval:				
47.14263 132.76848				
sample estimates:				
mean in group Mies mean in group Nainen				
	143.9556	54.0000		

Chart 3.8.

Variable: mobilitkiinnostaa				
	mean	sd	n	NA
Mies	2.5625	1.089725	48	0
Nainen	3.1600	0.746101	25	0
Analysis of Variance Table				

Response: mobiilitkiinnostaa					
	Df	Sum Sq	Mean Sq	F value	Pr(>F)
sukupuoli	1	5.869	5.869	6.0236	0.01657 *
Residuals	71	69.172	0.974		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Welch Two Sample t-test					
data: mobiilitkiinnostaa by sukupuoli					
t = -2.7559, df = 65.604, p-value = 0.00757					
alternative hypothesis: true difference in means is not equal to 0					
95 percent confidence interval:					
-1.0304224 -0.1645776					
sample estimates:					
mean in group Mies mean in group Nainen					
		2.5625		3.1600	

Chart 3.9.

We can see that on average boys are more interested in information technology and mobile technology than girls, and they also have higher self-confidence as users of information technology. The boys sit in front of the computers daily more than girls, while girls are more emotionally tied to their cell phones.

6.4. Some correlations

Spearman's rank correlation rho	
data: atkkiinnostavaa and mobiilitkiinnostaa	
S = 27383.69, p-value = 8.809e-08	
alternative hypothesis: true rho is not equal to 0	
sample estimates:	
rho	
0.5775687	

Chart 3.10.

Coefficient of determination between " In my opinion computers are interesting" and " In my opinion mobile devices are interesting." was 33 %.

Interesting correlations over 0.5 with small p-values were found the following. **Calculations in Charts 3.11-3.15 have been made in the set of SMS-users (onlysms).**

Spearman's rank correlation rho
data: onlysms\$atkkiinnostavaa and onlysms\$setakiinnostava
S = 4189.549, p-value = 0.001494
alternative hypothesis: true rho is not equal to 0
sample estimates:
rho
0.5033725

Chart 3.11.

Spearman's rank correlation rho
data: onlysms\$matikkatarkeaa and onlysms\$setamukavaa
S = 3441.303, p-value = 0.0001133
alternative hypothesis: true rho is not equal to 0
sample estimates:
rho
0.5920693

Chart 3.12.

Spearman's rank correlation rho
data: onlysms\$setaeasylearn and onlysms\$setamukavaa
S = 2440.772, p-value = 8.299e-07
alternative hypothesis: true rho is not equal to 0
sample estimates:
rho
0.7106719

Chart 3.13.

Spearman's rank correlation rho
data: onlysms\$setaeasylearn and onlysms\$setaeikayttoon
S = 14667.06, p-value = 1.798e-07

alternative hypothesis: true rho is not equal to 0
sample estimates:
rho
-0.7386276

Chart 3.14.

Spearman's rank correlation rho
data: onlysms\$atkkiinnostavaa and onlysms\$mobiilitkiinnostaa
S = 3761.409, p-value = 0.0003732
alternative hypothesis: true rho is not equal to 0
sample estimates:
rho
0.5541241

Chart 3.15.

Spearman's rank correlation rho
data: onlysms\$mobiilitkiinnostaa and onlysms\$setakiinnostava
S = 7254.535, p-value = 0.4084
alternative hypothesis: true rho is not equal to 0
sample estimates:
rho
0.1400504

Chart 3.16.

25% of the variability in “It was more interesting to study via MLE than only with pen and paper” can be explained by the variability on “In my opinion computers are interesting”.

36% of the variability in “It was nice to use MLE.” can be explained by the variability on “In my opinion mathematics is interesting.”

The most interesting couple of variables which have no correlation between them is in Chart 3.17.

Spearman's rank correlation rho
data: onlysms\$mobiilitkiinnostaa and onlysms\$setakiinnostava

S = 7254.535, p-value = 0.4084
alternative hypothesis: true rho is not equal to 0
sample estimates:
rho
0.1400504

Chart 3.17.

There is no correlation between “In my opinion mobile devices are interesting” and “It was more interesting to study via MLE than only with pen and paper”. Maybe we can think that for student’s content is more important than technology that mediates it.

6.5. Reliability and factor analysis

Coefficient of reliability was calculated with SMS-users. Meters for attitudes to mathematics (Chart 3.18) , to computers (Chart 3.19) and to MLE (Chart 3.21) have good reliability, but there is need to find better meter for attitudes to mobile technology (Chart 3.20). Attitude to social media would be an interesting “more female” meter to build up.

```
Alpha reliability = -0.6511
Standardized alpha = -0.2645

Reliability deleting each item in turn:
      Alpha Std.Alpha r(item, total)
matikannumero    0.6004    0.6047    -0.4061
matikkakiinostaa -0.2200    -0.2685    -0.2828
matikkatarkeaa  -1.8848    -2.3466     0.1801
```

Chart 3.18

```
Alpha reliability = 0.7807
Standardized alpha = 0.777 |

Reliability deleting each item in turn:
      Alpha Std.Alpha r(item, total)
atkkiinnostavaa 0.4376    0.4402    0.8300
atktarkeaa      0.8017    0.8022    0.5204
atkvarmanaolo   0.7885    0.7953    0.5399
```

Chart 3.19

```

Alpha reliability = 0.0256
Standardized alpha = -0.1604

Reliability deleting each item in turn:
              Alpha Std.Alpha r(item, total)
kannyero      0.0541    0.2103    -0.0314
kannylasku    -0.6745   -0.7095    0.0816
mobiilitkiinnostaa -0.0004   -0.0012    0.0752

```

Chart 3.20

```

Alpha reliability = 0.8007
Standardized alpha = 0.7618

Reliability deleting each item in turn:
              Alpha Std.Alpha r(item, total)
setaarvosan   0.8952    0.8923   -0.4302
setaeasylearn 0.6980    0.6460    0.8694
setaeasyuse   0.7254    0.6770    0.7624
setakertaus   0.7302    0.6695    0.7606
setakiinnostava 0.7619    0.7028    0.6145
setamukavaa   0.7338    0.6806    0.7430
setaoppimisuseful 0.7891    0.7435    0.4473

```

Chart 3.21

```

>all:
factanal(x = ~setaarvosan + setaeasylearn +
setaeasyuse + setakertaus +
setakiinnostava +
setamukavaa + setaoppimisuseful, factors = 2,
data = vainsms, scores = "none", rotation = "promax")

Loadings:
              Factor1 Factor2
setaarvosan   0.294  -0.938
setaeasylearn 1.054
setaeasyuse   0.627   0.404
setakertaus   0.887  -0.152
setakiinnostava 0.454   0.196
setamukavaa   0.416   0.595
setaoppimisuseful 0.529

              Factor1 Factor2
SS loadings   2.764   1.749
Proportion Var 0.395   0.250
Cumulative Var 0.395   0.645

Test of the hypothesis that 2 factors are sufficient.
The chi square statistic is 22.32 on 8 degrees of freedom.
The p-value is 0.00435

```

Chart 3.22.

In Chart 3.22 factor analysis for “attitude to MLE”- variables is calculated by Promax rotation. ”It was easy to learn to use MLE” and ”MLE suited well to revision” are loaded specially to factor 1. ”I give grade _ to MLE” and ”MLE was useful for learning” are loaded specially to factor 2. It is difficult to give names to these factors, so factor analysis doesn’t give anything in this case.

```
call:
factanal(x = ~atkkiinnostavaa + atktarkeaa + atkvarmanaolo + kannyero + kannylasku
|+ koneenkayttoaika + matikannumero +
matikkakiinnostaa + matikkatarkeaa + mobiilitkiinnostaa, factors = 2,
data = vainsms, scores = "none", rotation = "promax")
```

Loadings:

	Factor1	Factor2
atkkiinnostavaa	0.989	0.118
atktarkeaa	0.610	0.703
atkvarmanaolo	0.687	-0.121
kannyero	-0.342	-0.264
kannylasku	0.250	-0.419
koneenkayttoaika	-0.423	0.329
matikannumero		-0.243
matikkakiinnostaa		0.609
matikkatarkeaa		0.661
mobiilitkiinnostaa	0.581	0.166

	Factor1	Factor2
SS loadings	2.531	1.771
Proportion Var	0.253	0.177
Cumulative Var	0.253	0.430

Test of the hypothesis that 2 factors are sufficient.
The chi square statistic is 34.53 on 26 degrees of freedom.
The p-value is 0.122

Chart 3.23

I made an own analysis also for independent variables (Chart 3.23). To factor 1 loaded specially “In my opinion computers are interesting”, “When I work with a computer I feel myself confident” and “In my opinion mobile devices are interesting”. This factor could be named “interest to technology”. To factor 2 loaded specially “In my opinion mathematics is interesting”, “In my opinion it is important to have mathematical knowhow” and “Average of math courses of second year with scale 4 – 10”. This factor could be named “interest to content”.

6.6. Lessons learned from cycle one and two – what’s next?

What I have learned in the first three years of research 2005-2007 when I was building and evaluating MLE?

1. It is possible to build a cost-efficient and stable working mobile learning/information environment MLE with SMS-messages as mediating technology. It is easy to roll on it to an ordinary school and some parts of it all teacher can and want to take to use. It was my main research target at that time, so this case was closed.
2. All this can be done by one man with zero Euros budget with help of open source platforms (Debian, Kannel, phpMyAdmin, ...) and communities and with some hard PHP&MySQL coding work.

Mobile learning is still a land for frontiersmen. But are there any possibilities that mobile learning is coming to main stream e-learning? This question was still open.

3. It is a quite easy and fast to program new applications to MLE.
4. Students are waiting that there is no bugs in e-learning environments. That is not a surprise.
5. In school students are more interesting helpful tools for learning than new technology toys. Technology is not a value by itself, but only a mediator of learning. I don't see that the role of pure technology as motivator for students is so important, but some, even simple, gaming in mobile learning environment is quite motivating.
6. SMS is a good start, but MMS is needed, if I really want to teach larger entities like a whole math lesson with theory and exercises.
7. What is the relation between mobile learning vs. web-based learning environments like Moodle, which were coming to Finnish senior secondary schools 2005 - 2006? It must be solved, how these environments are interacting.

So the next mission was building of a mobile learning environment, which uses MMS-messages. That was the cycle three in my design science research. In the cycle four MLE-Moodle and Opit Binder was evaluated towards my own MLE environment. What is the future of mobile learning in the next decade?

7. The third cycle

7.1 Building of the artifact

The next main target was getting MMS-support to MLE. The Multimedia Messaging Service (MMS) provides a rich set of content to users (pictures, audio, videos etc). It supports both sending and receiving of multimedia content by properly enabled client devices.

I wanted that it is possible to use MMS-messages in MLE same way it was possible to use SMS-messages. Main component needed to get MMS working in MLE was two-way MMS-gateway. I was very lucky, because Mbuni open source gateway was published 2005. It broadens the Kannel code base in order to support sending and receiving MMS. It includes both core network MMS switching capabilities as well as messaging gateway features, and is suitable for operators and MMS value added service providers, such I was as mobile teacher.

Mbuni decodes incoming MMS into files (e.g.: pictures, text, and audio). Mbuni will pass the location of these multimedia contents to the control servlet. Outgoing MMS can be sent from command line or through HTTP request. (CoMobile)

Blogging was important part of new social media (Web 2.0: Blogs, Wikis, RSS, instant messaging, podcasting, social book marking etc.) concept that was growing up those days. A blog is a website in which entries are posted regularly and displayed in reverse chronological order. Moblog (mobile blog) sites consist of contents posted from mobile devices such as mobile phones or PDA by sending for example email, SMS or MMS. Moblog sites use mobile devices only for data submission.(CoMobile, Mobile Blogging)

The easiest way to compose a mobile blog message (text, photo, video, audio) is to do that in a MMS message and deliver it to the MMS blog. Every modern phone has capability to send MMS-messages, so no extra applications were needed on the client side.

7.1.2 Kannel and SMS

The Kannel project was founded by Wapit Ltd in June, 1999. Kannel is mainly an open source WAP gateway. One of the most popular technology for implementing mobile services early 2000 was WAP, short for Wireless Application Protocol. It lets the phone act as a simple web browser, but optimizes the markup language, scripting language, and the transmission protocols for wireless use. The optimized protocols are translated to plain old HTTP by a WAP gateway. In addition, Kannel operates as Push Proxy Gateway , or PPG, making possible for content servers to send data to the phones. I made also some effort to use WAP and WAP-Push for mobile learning, but WAP was going rapidly oldish 2005.

Mobile operators have a node in their network called an SMS Service – Centre (SMS-C) that handles SMS message traffic. Kannel also works as an SMS gateway for GSM networks. The quantity of companies using Kannel to successfully connect to a variety of SMSC protocols in lots of countries.

SMS, short messaging service, is a way to send short 160 character (this can be extended by combining a number of messages together) messages from one GSM phone to another. It can also be used to send regular text as well as operator logos, ringing tones, business cards and phone configurations.

SMS services are content services initiated by SMS message to certain phone number, which then answers with requested content.

To set up an SMS gateway, you need, in addition to a machine running Kannel, access to an operator's SMS center. If you do not have such access, you can still use Kannel as an SMS gateway via phone-as-SMSC feature, by using a GSM phone as a virtual SMS center. I used this virtual SMS center on my platform.

In addition to an SMS center, you need some server to handle any SMS requests received. This server then has simple or more complex cgi-bins, programs or scripts to serve HTTP requests generated by Kannel in response to received SMS messages. These services can also initiate SMS push via Kannel smsbox HTTP sendsms interface. In my context this server/services is MLE mobile learning environment.

After you have configured Kannel to allow the sendsms service, you can send SMS messages via HTTP, e.g., using a WWW browser. The URL looks something like this:

[http://smsbox.host.name:13013/cgi-bin/sendsms?](http://smsbox.host.name:13013/cgi-bin/sendsms?username=foo&password=bar&to=0123456&text=Hello+world)
username=foo&password=bar&to=0123456&text=Hello+world

Thus, technically, you make an HTTP GET request. This means that all the information is stuffed into the URL.

In mobile learning server Kannel is used

- a. to send and receive SMS messages with GSM-phone connected to server with USB or serial cable (virtual SMS center)
- b. with Mbuni to handle MMS with older phones.

My experience of Kannel is that it is reliable and speed of sending messages is good enough, about 6 messages per minute. Documentation is excellent and community of Kannel developers and users gives support actively. Setting up Kannel doesn't take for me very long first time. Problems I met on cycle one were solved by setting sim buffering on.

Kannel community is still active. Newest development version was released in 2010 and mailing list users@kannel.org gets messages daily in 2011.

7.1.3 Kannel configuration for MLS-server

Kannel consists of three boxes (programs): the bearer box is the interface towards the phones. The bearer box accepts WAP and SMS messages from the phones and sends them to the other boxes. The SMS box handles SMS gateway functionality, and the WAP box handles WAP gateway functionality. There can be several SMS boxes (for example two phones connected to server with USB cables) and several WAP boxes running and this makes it possible to handle much larger message loads.

To start the gateway, you need to start each box you need. You always need the bearer box, and depending on whether you want WAP and SMS gateways you need to start the WAP and SMS boxes.

There is only one configuration file for all parts of Kannel, which can be divided into three parts: bearerbox configurations, smsbox configurations and wapbox configurations. Bearerbox part has one 'core' group and any used SMS center groups, while wapbox part has only one wapbox group. In smsbox part there is one smsbox group and then number of sms-service and sendsms-user groups.

To set up the SMS center at Kannel, you have to add a 'smc' group into configuration file. Here is this group with comments:

```
group = smc

smc = at

#M.S: put here your modem type, look to end of this file
#to find your modemtype or use auto

modemtype = nokiaphone

#M.S.: put here the port where phone is connected

#serial port like

device = /dev/ttyS0

#usb-port like

# device = /dev/ttyACM0

# M.S: pin of the phone

pin = 1234

sim-buffering = true
```

Here are typical settings for smsbox

```
group = smsbox
bearerbox-host = localhost
sendsms-port = 13013
global-sender = 13013

group = sendsms-user
#M.S.: Tell here username and password and put these
#also to sms/include/sms2.php
username = your.own.username.here
password = your.own.password.here
max-messages = 3
```

```
concatenation = true

#M.S.:message to sms-blog
group = sms-service
keyword = www
get-url =
"http://localhost/sms/get/getsmswww.php?text=%r"
accept-x-kannel-headers = true
concatenation = true
max-messages = 3
```

so you can now send SMS by

[http://smsbox.host.name:13013/cgi-bin/sendsms?](http://smsbox.host.name:13013/cgi-bin/sendsms?username=foo&password=bar&to=0123456&text=Hello+world)
username=foo&password=bar&to=0123456&text=Hello+world

and if MLS gets SMS-message from student starting with word www (group = sms-service) , then rest of message goes to PHP-program getsmswww.php for processing.

7.1.4 Mbuni and MMS

In this part are used references Mbuni 2007 and Loubser 2005.

The Multimedia Messaging Service (MMS), is intended to provide a rich set of content to users (pictures, audio, videos etc). It supports both sending and receiving of multimedia content by properly enabled client devices. MMS is a non-real-time delivery service, much like SMS or email. MMS uses a store-and-forward usage model. The user submits a message to a message center, where it is stored and sent to another user when possible.

MMS is designed to be transported over IP rather than traditional GSM networks. It is also designed to interoperate with other IP services such as email and WAP. MMS messages are typically transported over WAP, and are encoded using WAP MIME formats.

Multimedia messages can be composed by or terminate to end-user client devices (MMS-phones) or third party applications (used by MMS content providers). In the MMS architecture, the MMSC acts as the message-switching system within the core network, while the MMSBox acts as the message dispatch and content management system on the VAS (third party) side. The overall architecture is shown below.

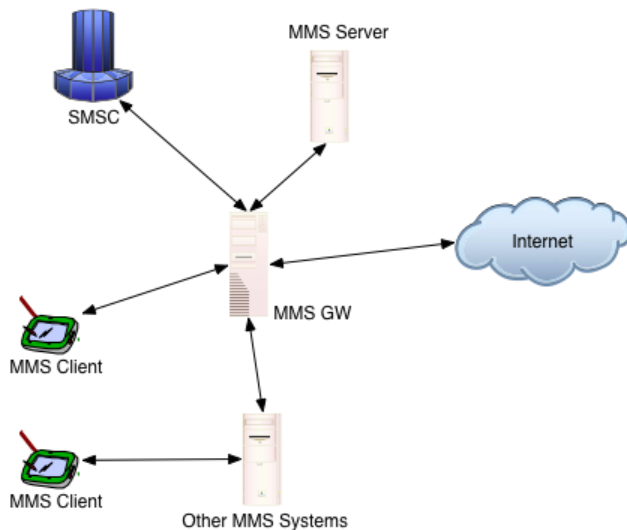


Figure 7. From www.mbuni.org

The elements shown in the figure can be summarised as follows:

MMS Client: A device through which the user receives or sends multimedia messages. This might be a phone or a PC-based MMS client. The Client sends messages to and receives messages from the MMSC using WAP/HTTP as transport.

MMS Gateway: Switches messages between different MMS clients and between MMS and Email. The Gateway may also interface with other gateways to exchange messages destined for foreign networks. This is also more properly known as the MMSC.

MMS Server: This component provides persistent storage of messages on the network. Typically users can access stored messages via a web interface.

Other MMS Systems: Other systems, such as Third Party MMS systems (e.g. MMS VAS Value Added Services providers) can interface to the MMSC to receive and send MMS content. A VAS could be ringtones, pictures, or videos sent via MMS or a mobile blogging, which I had used.

SMSC: The MMSC utilises WAP Push to send notifications about incoming messages to MMS Clients. These are typically sent using SMS (text message) as the bearer service, hence the need for a link to a Short Message Service Centre. I have used Kannel as SMSC.

The message cycle begins typically with a user sending a multimedia message (MM) from the MMS client. The client must be configured for MMS, which includes bearer settings (i.e. 3G, GPRS or GSM/CSD settings), WAP gateway address and MMS Gateway address (a URL). On receipt of the message, the MMSC decides how to deliver the message (e.g. to another MMS client or to a VASP), and proceeds to dispatch the message. A VASP may also originate a message to the MMSC, for onward delivery.

For the network "operator" Mbuni includes a fully-fledged MMS switching centre (MMSC). For the MMS content provider Mbuni includes a MMS Value Added Services (VAS) Gateway (MMSBox).

I installed Mbuni to my Debian Etch Internet-server as MMSC and as VAS Gateway. When MMS-phone is configured to use my server as MMSC (it is possible to use many configurations, so it is easy to change to ordinary MMSC of phone operator), MMS-messages goes from client to MMSC, from MMSC to VAS Gateway and from VAS Gateway to my MMS-blog.

Blogger pays only normal GPRS-data price when sending message to blog, but if he or she has data packet (for example 25 Mt per month) this is in practise free to blogger. When phone operators MMSC is not used in this blogging, MMS-message price is saved, only GPRS-data price is cost of message.

First version of Mbuni published 2005 by Digital Solutions Ltd. It was very important to my research and 2003 when I started, I haven't any idea that this kind of free product was coming. Mbuni community was very active that time and has been helpful for my research. My interaction with community can be read on page <http://www.mail-archive.com/search?q=mika+setälä&l=users%40mbuni.org>.

Setting up Mbuni was very hard work. It take from me many months to get all working.

Mbuni community is still active and the newest version was released in 2011. Mailing list users@mbuni.org is quite silent nowadays. General popularity of MMS-messages is going down, because of mobile Facebook etc.

7.1.5 Mbuni configuration for MLS-server

To run Mbuni, you must run three boxes (programs) mmsbox, mmsrelay and mmsproxy.

mmsbox is the VAS gateway. This program performs many simultaneous functions, including receiving incoming MM from MMSCs, dispatching requests to services, composing and sending responses, and listening for and handling sendmms requests.

mmsrelay is the main relay server of the MMSC. It routes incoming messages to MMS clients/handsets, email, other MMS gateways, etc. It also manages routing messages to MMS clients using WAP Push, sending of delivery reports, etc.

mmsproxys is the main point of interaction between the gateway and MMS clients and VASPs. mmsproxy provides the HTTP interface of the MMSC via which messages are sent and received by MMS clients.

Mbuni starts by giving commands

mmsbox mbunivasp.conf &

mmsrelay mbuni.conf &

mmsproxy mbuni.conf &

You must have Kannel SMSC and Kannel Wap Gateway running before that.

Here are main parts from mbuni.conf with comments.

```

group = mbuni
#give a name
name = "Mymmc"
#use your own domain name here
hostname = mobbie.dynalias.net
#use your own domain name here
host-alias = mobbie.dynalias.net:8191
#local-mmsc-domains = mobbie.dynalias.net
local-prefixes = 050;+35850;35850
max-send-threads = 5
send-mail-prog = /usr/sbin/sendmail -f '%f' '%t'
storage-directory = /var/spool/mbuni
sendsms-url = http://mobbie.dynalias.net:13013/cgi-bin/sendsms
#check these from smskannel.conf, from group sendsms-user
sendsms-username = your.own.username.here
sendsms-password = your.own.password.here
queue-run-interval = 5
mms-port = 8191
mm7-port = 8192
content-adaptation = false

```

```

group = mms-vasp
vasp-id = mikan
type = eaif
short-code = 100
# but there your own username and password
vasp-username = hotdog
vasp-password = bobcat
# but there your own username and password and IP
vasp-url = http://hotdog:bobcat@98.293.81.218:8080/mm7

```

Here are main parts from mbunivasp.conf with comments.

```

group = mbuni
#give a name
name = "yourvasp"
max-send-threads = 5
storage-directory = /var/spool/mbuni
queue-run-interval = 5
sendmms-port = 8193

group = mmsc
#give a name
id = myownmmsc
#change username and password and IP
mmsc-url = http://hotdog:bobcat@98.293.81.218:8192/eaif
#change username and password
incoming-username = hotdog
incoming-password = bobcat
incoming-port = 8080
type = eaif

group = send-mms-user
#change username and password
username = hotdog
password = bobcat
faked-sender = 100

```

```
# These keywords (first word of MMS-messages text-part) sends MMS-#
messages to right php-codes
```

```
group = mms-service
name = kisa
keyword = puukisa
#change IP
post-url = http://98.293.81.218/sms/get/getmmstopuukisa.php
http-post-parameters =
text=%t&image=%i&video=%v&smil=%s&audio=%a&binary=%b
accept-x-headers = true
text = ok
```

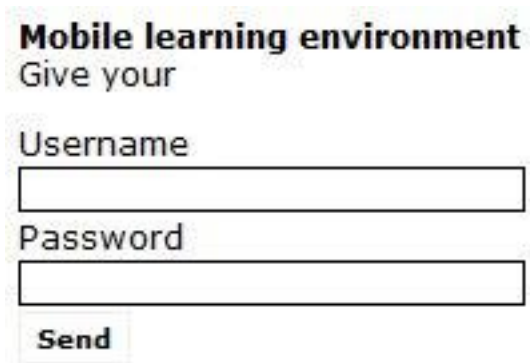
```
group = mms-service
name = mobile
keyword = toweb
catch-all = true
#change IP
post-url = http://98.293.81.218/sms/get/getmmstoweb.php
http-post-parameters =
text=%t&image=%i&video=%v&smil=%s&audio=%a&binary=%b
accept-x-headers = true
text = ok
```

If MLS gets MMS-message from student starting with word toweb (group = mms-service) , then rest of message goes to PHP-program getmmstoweb.php for processing.

7.1.6 MLE

Here are some picture captures from MLE.

First user must login to system with username and password.



Mobile learning environment
Give your

Username

Password

Send

Sending SMS happens this way:

Main page	Send message	Send groupmessage	Send message to guidancegroup
Send MMS-message	Add photo	Add text	Blogs
Add a new student	Add a new course	Add a new group	Add a student to school
Mikan sivu			

Write message

From:
Mika Setälä

sms message

Welcome to ...|

14 characters (max. 160)

To:

Pupils

Select	First name	Second name	Guidancegroup	Phone	Id
<input type="checkbox"/>	Lassi		06E		1
<input type="checkbox"/>	Ali H		06E		2
<input type="checkbox"/>	Suvi		06E		3
<input type="checkbox"/>	Karita		06E		4

Sending message to group of students happens like this:

Write message

From:
Mika Setälä

sms message

Remember test tomorrow! t. Setälä|

31 characters (max. 160)

To:

Select	Name	Info	Id
<input type="checkbox"/>	KaikkiOppilaat	Koulun kaikki oppilaat	1
<input checked="" type="checkbox"/>	Math course	MAA1	3
<input type="checkbox"/>	Chemistry course	KE1	4



Send SMS

Sending MMS is this kind of process, where you select image, text and receiver.

Send message

From:
Mika Setälä

Message:

Select	FileName	
<input checked="" type="checkbox"/>	ruusu.jpg	
<input type="checkbox"/>	hyonteinen.jpg	

Select	FileName	
<input type="checkbox"/>	sometext.txt	sometext.txt
<input checked="" type="checkbox"/>	moblearn.txt	moblearn.txt

To:

Pupils

Select	First name	Second name	Guidancegroup	Phone	Id	Use also MMS
<input checked="" type="checkbox"/>	Lassi		06E		1	<input checked="" type="checkbox"/>
<input type="checkbox"/>	Ali H		06E		2	<input type="checkbox"/>
<input checked="" type="checkbox"/>	Suvi		06E		3	<input checked="" type="checkbox"/>
<input type="checkbox"/>	Karita		06E		4	<input type="checkbox"/>

7.2. Evaluation of the artifact



7.2.1 Competition: Who finds the biggest tree of the forest?

Matti Kari used MLE in one part of his Master of Science Thesis “Mobile Devices in Forest Learning”. Kari’s thesis examines the use of mobile phones as a data gathering tool in forest learning.

In this experiment target group was 25 basic education four grade pupils. The task was to find the thickest tree nearby, take the picture and diameter, and send a multimedia message to the Internet server. That message also included location information from GPS receiver.

Pupils don’t trained tasks in advance and the instructions were given only in the forest. Participants were divided into three groups, which had four members. Each group had access to a mobile phone, GPS receiver and a tape measure.

Data went to WWW-page, where it can be seen immediately. The teacher could already in the forest to check from her mobile phone's WWW-browser that all the groups managed to task.

PUUKISA		Paulaži	Läpimitta (cm)	Sijainti	Nimi	Aika	KJ	y	x
Kuva		mänty	33	kartta	honkaset	24.04.07 11:47:39	kkj	6812000	3233000
		koivu	25	kartta	raudukset	24.04.07 12:35:00	kkj	6812010	3233010

GPS-data was connected with WWW-link to map-application (of National Land Survey of Finland), which gives the map of the area, where that tree is.

Phone use went smoothly and all the groups succeeded in sending MMS- message. Over 70% of pupils felt that sending a message was easy.

This application was typical example how mobile learning server makes possible rapid creating of mobile learning applications. Application was developed in less than three days.

7.2.2. A MMS-blog of religion course and MMS- excursion diary

I was using MMS-blog in religion course of upper secondary school. I give to my students free hands to take photos and videos about themes of course. They can comment their own shots and each others shots on the blog. Pupils have used camera phones photo and video editing software before sending their shots to blog.



Figure3. A snow angel



Photo from blog which has edited with phones photo editor

Group of student was in excursion in Sweden. They have very active live MMS-diary with photos and videos about their trip, which was followed rest of our students in school. The system was working well in Swedish GSM/3G-network. Due to high data prices between Sweden and Finland, this communication was not as cheap as in Finland.



Figure 4. Sweden calling

References

CoMobile: Collaborative Learning with Mobile Devices

Duc Phuong Nguyen, Martin Guggisberg, Helmar Burkhart

Computer Science Department, University of Basel

50 Klingelbergstr, CH-4056, Switzerland

Phuong.Nguyen@unibas.ch

<http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1652443>

Mobile Blogging: A Guide for Educators Paper presented at the MLearn 2007 - Making the Connections 6th International Conference on Mobile Learning, Melbourne

http://web.me.com/thom_cochrane/MobileWeb2/Research_Outputs/ConferenceProceedings/mLearn2007Paper1.pdf

TÄRKEÄ:

http://web.me.com/thom_cochrane/MobileWeb2/conferencepapers.html

8. The fourth cycle: making MLE ready for production use

8.1 Building of the artifact

All programmers are optimists -- Frederick P. Brooks, Jr.

I have a hope that mobile learning environment I build would be taken to use by another teachers in Finland or why not all over the World. MLE was not ready to serious production use at that moment.

For example, I must solve how to organize backup and security of the system. Mobile learning systems contain important information in the form of student data, course and announcement material. Possible system crashes can cause the loss of this information. Spam and viruses are reality also in the mobile world. Also, the hackers should be kept outside the system. Municipalities and the schools IT support does not allow any systems in which these issues are not taken care of.

I was not now building only a mobile learning environment MLE, but a whole multilevel mobile learning platform.

Mobile learning server (MLS) consists of two parts, server core platform (SCP) and mobile application platform (MAP). MLS makes it possible to rapidly and easily to construct applications for mobile learning which together constitutes a mobile learning environment (MLE). I don't see any more that my mission is to produce a monolithic ready mobile application, but a platform for producing different kind of mobile learning applications like MMS blog, SMS voting systems, SMS learning games etc. The platform has been designed to be not just a monolithic application providing a fixed set of features, but to be modular and extendable to a high degree.

<u>MLE</u> MMS blog SMS learning games	
<u>MAP</u> MMS-Gateway: Mbuni SMS-Gateway: Kannel	<u>MLS</u> MAP + SCP
<u>SCP</u>	

Operating system: Debian Linux Reliability: Raid and rdiff Web server: LAMP Mail system : Postfix and Squirrelmail Proxy: Squid and DansGuardian Tools against spam and viruses: SpamAssassin and Clam AntiVirus Firewall	
--	--

8.1.2 Server core platform

LAMP

The LAMP stack includes the Linux operating system, Apache Web server, MySQL database, and scripting language PHP (or Perl or Python). The LAMP stack is a loose collection of open source components that developers can combine to build various types of Web applications. LAMP offers lower costs, greater flexibility, and faster improvements in the component technologies. (Lawton 2005)

Raid and rdiff

Disk arrays need some form of redundancy to improve reliability. The most common and cost effective solution to improve the reliability of disk systems is the use of Redundant Array of Independent Disks (Raid). A RAID system stripes data across multiple hard disks that appear to the user as a single disk. The various levels of RAID specify different methods of redundancy, such as parity and mirroring, to provide reliability. (Chandy 2008)

Mirroring, or RAID1, entails replication of the data on multiple disks. The same data is stored in two (or more) separate disk. In case of the dissolution of the second disk, all data is saved. I used this RAID1 in SCP by using two identical hard disks.

Rdiff-backup backs up one directory to another over a network. The target directory ends up a copy of the source directory, but extra reverse diffs are stored in a special subdirectory of that target directory, so you can still recover files lost some time ago. (Debian 2011)

Mail server : Postfix and Squirrelmail

Postfix is a mail transport agent that started life as an alternative to the widely-used Sendmail program. Postfix attempts to be fast, easy to administer, and secure. (Lenny 2011) Postfix continues to be actively developed.

Mail transfer agent (MTA) is the software that sends e-mail. This e-mail is sent by the client that the user has used to compose and send the message. This recipient MTA sends the e-mail to an MDA (defined next). SMTP is an example of a protocol that can be used by an MTA to deliver e-mail. (Vugt 2009)

Mail delivery agent (MDA) works together with the MTA on the server that is used by the recipient. The MDA makes sure the e-mail is stored in a location in which the user can access it. Postfix comes with an integrated MDA as well. (Vugt 2009)

SquirrelMail is a standards-based webmail client. It enables the access of email and address books from anywhere in the world with WWW-browser. (Squirrelmail 2011)

Postfix is needed for running Mbuni.

Proxy: Squid and DansGuardian

An HTTP proxy such as Squid is needed for running Mbuni, since some newer phones do not send MMS over WAP but directly over HTTP via an HTTP Proxy.

Squid is a caching proxy for the Web supporting HTTP, HTTPS, FTP, and more. It reduces bandwidth and improves response times by caching and reusing frequently-requested web pages. It has grown to include extra features such as powerful access control, authorization, logging, content distribution/replication, traffic management and shaping. (Squid 2011)

With squid it is possible to allow only MMS-messages for HTTP traffic by writing to squid.conf

```
# mime type settings by Mika S.,  
# only MMS-messages allowed for proxy-traffic  
acl mimeokq req_mime_type ^application/vnd.wap.mms-message$  
acl mimeokp rep_mime_type ^application/vnd.wap.mms-message$  
  
http_access deny !mimeokq  
http_reply_access deny !mimeokp  
http_access deny !mimeokq  
http_reply_access deny !mimeokp
```

DansGuardian is an web content filter. It filters the actual content of pages based on many methods including phrase matching, PICS filtering and URL filtering. It does not purely filter based on a banned list of sites like lesser totally commercial filters. It check every page you ever access for 'bad' subjects such as drugs, profanities, hate, pornography, etc, and disallow it if it's not suitable. This is called 'Content Filtering'. (Dansguardian 2011) Dansguardian was connected to Squid to adding more safety.

Safety tools against spam and viruses: SpamAssassin and Clam AntiVirus

SpamAssassin is a widely used open source spamfilter. It is made up of about nine hundred tests, each of which is aimed at detecting a given characteristic of spam emails like the presence of a given keyword in the emails text or some kind of email's header malformation. (Xu 2009)

ClamAV is an open source antivirus engine designed for detecting Trojans, viruses, malware and other malicious threats. It is used for mail gateway scanning. It provides a high performance mutli-threaded

scanning daemon, command line utilities for on demand file scanning, and an intelligent tool for automatic signature updates. (Clamav 2011)

SpamAssassin and ClamAV are needed for making SCP safe enough for real production server.

Firewall

iptables is the current Linux firewall mechanism, which purpose is packet filtering based on for example IP addresses and TCP ports. Only ports really needed was let open in SCP.

After server is installed, it should be checked with vulnerability scanner like Nessus. Nessus features high-speed discovery, configuration auditing, and asset profiling, sensitive data discovery and vulnerability analysis of your security posture. (Tenable 2011)

8.1.3 Mobile application platform

Mobile application platform builds up from SMS Gateway Kannel and MMS Gateway Mbuni. It has been described in chapter 7.

8.1.4 Mobile learning environment MLE

MLE has been described in chapters 1 – 7.

8.1.5 Extension of MLE

MLE is based on SMS and MMS messages. By installing on MLS Mobile Moodle and MLE-Moodle you can get also support for mobile learning with WLAN and mobile broadband connections. MLE-Moodle is described in chapter 9.

MLE	MLE-Moodle
MAP	MLS:
SCP	MAP + SCP

Sources

Lawton, G.; , "LAMP lights enterprise development efforts," *Computer* , vol.38, no.9, pp. 18- 20, Sept. 2005
doi: 10.1109/MC.2005.304

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1510562&isnumber=32339>

Tenable 2011

<http://tenable.com/>

Clamav 2011

<http://www.clamav.net/>

Xu 2009

Training SpamAssassin with Active Semi-supervised Learning

In: **Proceedings of the 6th Conference on Email and Anti-Spam (CEAS'09)**, Mountain View, CA, 2009.

http://prag.diee.unica.it/prag/system/files/Xu_CEAS2009.pdf

John A. Chandy

RAID0.5: design and implementation of a low cost disk array data protection method

THE JOURNAL OF SUPERCOMPUTING

Volume 46, Number 2, 108-123, DOI: 10.1007/s11227-007-0159-8 2008

Debian 2011

<http://packages.debian.org/unstable/utils/rdiff-backup>

Lenny 2011

<http://packages.debian.org/fi/lenny/postfix>

van Vugt 2009

PRO UBUNTU SERVER ADMINISTRATION 2009, 249-280, DOI: 10.1007/978-1-4302-1623-0_10 Apress

Squirrelmail 2011

<http://squirrelmail.org/about/>

Squid 2011

<http://www.squid-cache.org/>

Dansguardian 2011

<http://dansguardian.org/>

8.2 Evaluation of the artifact

I have published specifications and exact building instructions of MLS in my blog vps.virtuaalikoulu.org/mle. With these instructions schools teacher of information technology or it-support person can build own server and teachers can begin to use MLE and develop own models of using mobile learning.

Here are number of visitors in my blog. There was a quite a lot interest to my mobile learning environment.

	Tam	Hel	Maa	Huh	Tou	Kes	Hei	Elo	Syy	Lok	Mar	Jou	Yhteensä
2008			476	378	145	175	212	206	151	105	182	173	2 203
2009	233	213	245	315	303	311	237	151	208	263	232	204	2 915
2010	268	198	240	192	219	176	169	255	254	193	201	105	2 470
2011	126	202	159										487

Here is top twelve articles from the blog. So there has been about 130 persons how was interested the code of MLE.

Top Posts for kaikki days ending 2011-03-31 (Summarized)

Frontpage	3 391
Installing MMS-gateway Mbuni	1 394
Installing SMS-gateway and WAP-gateway Kannel	891
Scientific methods and examples of use of the mobile learning server	465
Howto build a SMS or MMS-game with MLE	218
SOME DESIGN PATTERNS FOR MOBILE LEARNING SERVER	187
Installing first parts of server core platform	174
Installing MLE	164
Sourcecode of mobile learning environment MLE	138
<u>FH JOANNEUM:s Mobile Moodle</u>	74

MMS-messages on the teaching of mathematics	53
Installing firewall and testing security	51

Here is Google search words that led to my blog.

Etsi	Näyttökerrat
mbuni.conf	113
mbuni	105
mobile learning environment	99
mbuni howto	69
mobile learning	37
action research	36
mbuni mms gateway	36
mbuni mms	32
mobile moodle	30
moodle kannel	28
install kannel	20
mobile learning server	17
apt-get install kannel	17
action research examples	17
mbuni conf	16
kannel mms	14
mobile learning environments	12
open source mobile learning	11
moodle mobile	11
parameters for development of m-learning with pdf	11
kannel sms gateway	11
installing mbuni	10
researches for mobile learning virtual campus"pdf"	10
mms mbuni kannel	10
mbuni en debian	10
kannel mle	9
mbuni debian	9
action research design	9
mobile learning source code	8
installing kannel	8
moodle mobile learning	8
howto using mbuni	8
sms gateway kannel	7

mobile learning moodle	7
"action research"	7
mbuni postfix	7
mbuni example	7
action research definition	7
kannel moodle	7

8.3 MMS-messages in the teaching of mathematics

8.3.1. Mobile learning and mathematics

Teaching of mathematics has been mobile almost 30 years, much earlier than the hype of m-learning started.

Usually when we talk about mobile learning, tools used in these projects are mobile phones, PDA:s and laptops. Electronic calculators has been used in schools from early eighties and they are also truly pocket sized portable technologies. New graphical calculators can plot curves, solve equations, have also some limited communication capabilities and are programmable, so these little computers gives many pedagogical opportunities to teachers.

Mobile learning case studies cant be find many in area of teaching of mathematics.

The Math4Mobile project of University of Haifa examines the opportunities of using the mobile phone for teaching and learning mathematics. There are five Java applications which can be installed to Java supporting phones and which make phones work like graphical calculators. These applications are designed to help pupil to learn intuitively about mathematical concepts like quadratic equations, quadrilaterals and derivative.

Mobile Mathematics Tutoring (MoMT) of University of Electro-Communications (Japan) is a personalized mobile mathematics tutoring system for primary students based on individual learner's abilities. It is combination of anytime, anyplace access to personalize customized mathematics exercises with a multimedia discussion space (multimedia- message by email) to get help or share ideas and experiences. MoMT provides tutors for four kinds of integer operators (+, -, *, /). When a learner logs in, MoMT analyzes his or her learning context and provides customized tutoring based on his previous learning state.

[Yerushalmy, M (2006) Math4Mobile: Ubiquitous Technology for Mlearning.

Software tools and site for mathematical learning and communication.

(M.Yerushalmy, A. Weizmann & Z. Shavit – Developers). Published by the Institute

for Alternatives in Education, University of Haifa. <http://www.math4mobile.com/>]

8.3.2.The anatomy of MMS-messages

MMS is abbreviation for the Multimedia Messaging System. It is the evolution of the popular Short Messaging System (SMS), which is a system for sending and receiving only text-based messages. MMS is very different from SMS.

- MMS is capable of handling of multimedia objects: images, audio, video and rich text.
- MMS offers also support for different messaging standards such as email. It is not only phone-based system, it is more like Internet-based communication tool.
- MMS messages can be thought of as slide shows, much like PowerPoint-presentations. Often

messages are shows with only one slide, but they are slide shows nonetheless. Each of the slides has its display area divided into different sections, such that the slides themselves are really just frames that hold the content, which is kept separate. The layout, ordering and timing of the slides is controlled with a language called SMIL.

8.3.3.Using MMS in mobile learning

There is not much case studies where MMS-technology has been used in real learning situations.

mediaBoard

City College Southampton used MMS-enabled phones in classes in English for speakers of other languages. They used mediaBoard-tool, which is a web-based multimedia message board which can receive SMS and MMS messages from mobile phones via a dedicated email address.

One aim was extend learners knowledge of the locality. Tutors upload an image onto the board and create zones within it. Learners send information from each zone as pictures, text messages and audio files. Tutors found that use of camera phones with web publishing developed also learners linguistic skills in real and meaningful ways.

There was some technical difficulties like some occasional breakdowns in service of mediaBoard, MMS messages were occasionally delayed and operators reconfigured their picture messaging format and so prevented the server from picking up messages.

Lecture feedback system with MMS

Nanyang Technological University used MMS messages as an communication medium between the lecturer and students during lectures. They have developed a system that allows instant feedback on teaching using MMS on the NTU's campus Wireless LAN.

During lectures, students can ask questions, response to questions or give immediate feedback on the lecture by MMS message. The lecturer himself can immediately respond to the comments so as to adjust to the learning needs of the students.

With this tool immediate assessment on courses can also be done. Interactive pollings can be carried out during lecture by having the lecturer sending out the question to students as MMS messages. The students' answers will be sent back to the lecturer and the average results can be calculated, tabulated and reviewed on the spot.

Sending MMS messages on the Wireless LAN will be free to students on campus. MMS messaging is extensible to the mobile GSM networks, so students can use it also outside of campus. System encouraged students to be more participative in the learning process, since usually students tend to be shy to speak up in large groups.

[\[www.succeed.ufl.edu/icee/Papers/195_MMS_final_ICEE2004_\(1\).pdf\]](http://www.succeed.ufl.edu/icee/Papers/195_MMS_final_ICEE2004_(1).pdf)

[\[http://portal.m-learning.org/mboard.php\]](http://portal.m-learning.org/mboard.php)

[\[http://www.jisc.ac.uk/uploaded_documents/southampton.pdf\]](http://www.jisc.ac.uk/uploaded_documents/southampton.pdf)

8.3.4. How to build a MMS-message with mathematical content?

To produce mathematical text in e-learning environments is not so easy, so in m-learning this is even bigger challenge.

LaTeX is a document preparation system which includes features designed for the production of technical and scientific documentation. LaTeX is the de facto standard for the producing of mathematical text on the Web, so I selected it to get mathematical formulas to the mobile phones.

GPL licensed TeXnicCenter was my tool for building LaTeX documents to PostScript page description language. With free software GSview I converted PostScript document to 256-color BMP-picture with resolution 600. Then I changed BMP-picture to GIF-format and to mobile size like 142 x 200 pixels.

Teachers voice was recorded and edited with GPL licensed Audacity software. I converted wav-file with Nokia Multimedia Converter 2.0 to WB-AMR audio file format.

With Nokia Mobile Internet Toolkit it is easy to compose MMS-message from audio, image and text files with smil-language.

8.3.5. Mathematical content and students participated to the experiment

There were two groups of students that participated to this mobile learning experiment. The first group A (N=33) was first year upper secondary school students (age 16-17), who studied linear Diophantine equations. The second group B (N=47) was second year upper secondary school students (age 17-18) and they studied the sum of the arithmetic sequence. Mathematical contents were typical parts of syllabus and included definitions, formulas, proofs, examples and exercises and all of them were presented as MMS-messages.

8.3.6. Learning environment

MMS-messages were like little PowerPoint-presentations with teachers voice recorded to the background.

Aritmeettisen lukujonon
(a_1, a_2, \dots, a_n)
summa on
$$S_n = \sum_{i=1}^n a_i = n \cdot \frac{a_1 + a_n}{2}$$

eli termien lukumäärä
kertaa ensimmäisen ja
viimeisen termin
keskiarvo.

Todistus: Olkoon
ensimmäinen termi a_1 ja
erotusluku d .
Jonon n :n ensimmäisen
termin summa voidaan
laskea alusta loppuun
tai lopusta alkuun

Eli toisaalta
 $S_n = a_1 + (a_1 + d) + \dots + (a_1 + (n-1)d)$
 ja toisaalta
 $S_n = a_n + (a_n - d) + \dots + (a_n - (n-1)d)$
 Mitä saadaan laskemalla nämä allekkain yhteen?

$2S_n = (a_1 + a_n) + (a_1 + a_n) + \dots + (a_1 + a_n)$
 eli
 $2S_n = n(a_1 + a_n)$
 Josta summakaava saadaan jakamalla puolittain kahdella.

Slides 1,2,3 and 4: Proof; formula of the sum of the arithmetic sequence

Students can watch MMS-messages from their phones or from the Internet. It was possible to move messages from computer to student's phone via cable or via Bluetooth. I also send messages to all students via operators 3G-network as ordinary MMS-messages. I used Nokia N70 phone and Nokia PC-suite to sending messages as mass MMS-messages. I don't use MLE and Mbuni to this, so MMS sending with MLE is only beta tested.

Also exercises were sanded as MMS-messages. Tasks were like this:

"Steps of Nikolai church in Helsinki are light up with lamps. Uppermost step has 1 lamp, second 2, third 3, ... etc. To this were needed 1081 lamps. How many steps there were? (Final exam year 1880)"

If you answer was wrong, you got tips one by one as SMS- message to your phone or from WWW-page:

"Mark number of steps with x",

"Equation $1+2+3+\dots+x = 1081$ ",

"Use formula for the sum of the arithmetic sequence and you get $x*(1+x)/2 = 1081$ " and last tip

"With the formula for second degree equation you get $x=46$ "

The last tip was always the right answer.

Some gaming function was created by giving points from the right answer and you get more points if you use less tips. Students have possibility to see results of this game in real time on the WWW-page.

8.3.7. Background information about students in these experiments

Gender, age and method of study

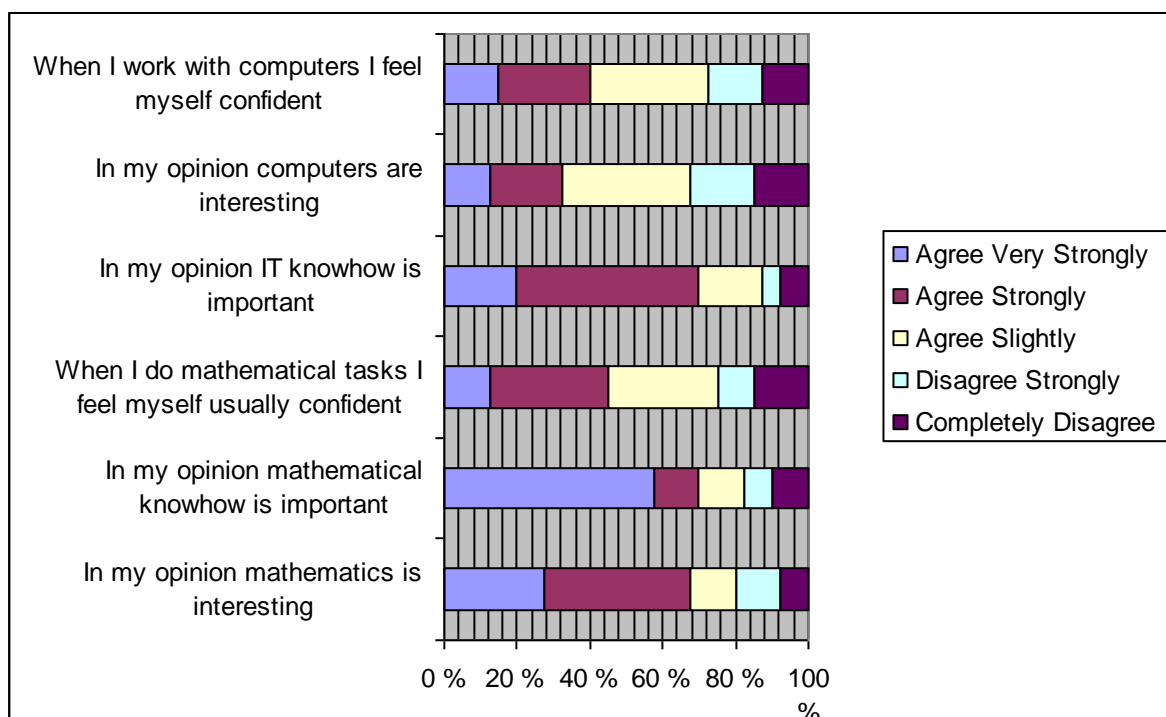
From the answerers were 50 % men and 62.50 % from group B (second year students).

Students had freedom to choose their method to study in this mobile learning experiment.

Method of study		
	frequency	percent
only WWW	9	22.50%
only phone	6	15.00%
only book	5	12.50%
no study	4	10.00%
www and also book	11	27.50%
phone and also book	4	10.00%
other	1	2.50%
sum	40	100%

Attitude to mathematics and IT

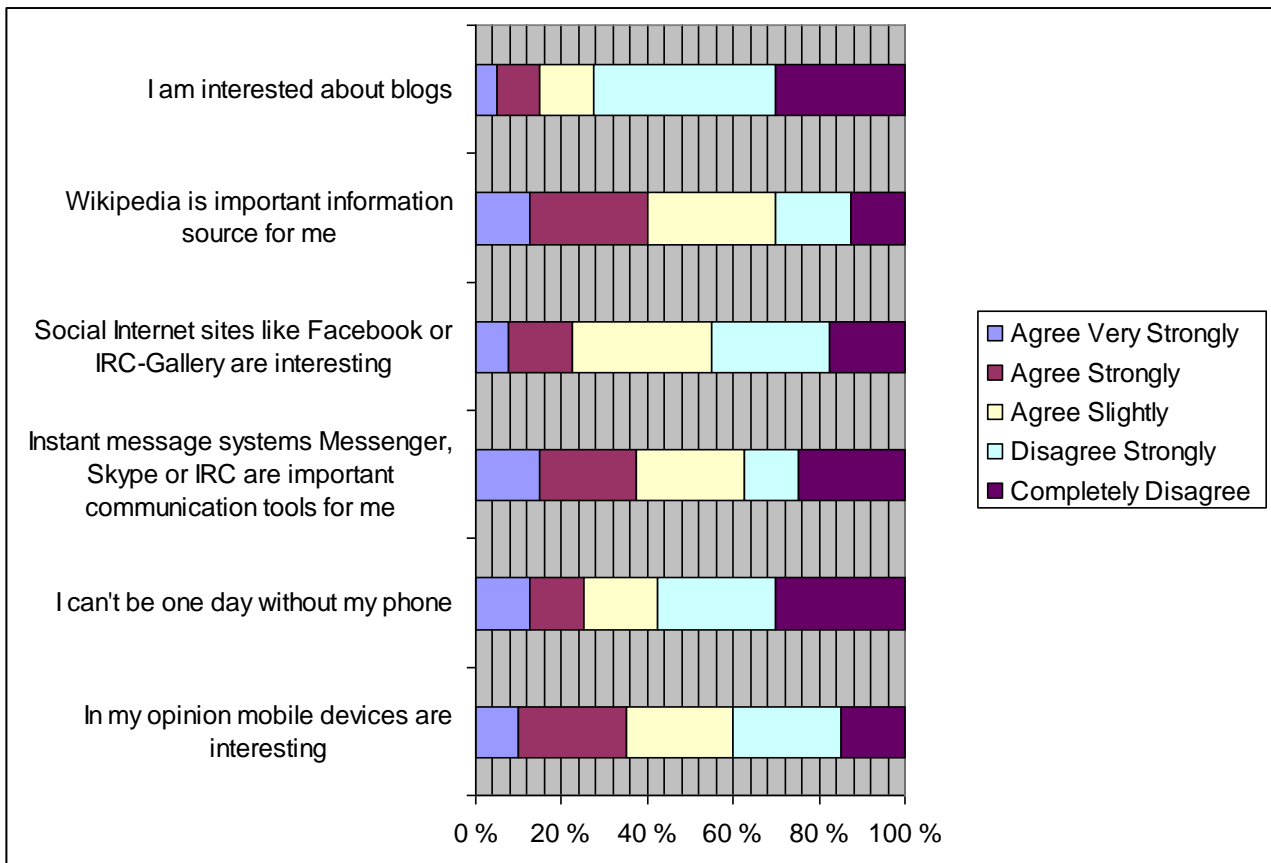
They have all computers at home. They have all used Moodle learning environment in high school. In average they have used Moodle in six courses.



These students think that both mathematical and IT knowhow are important, but they are more interested about mathematics than computers.

Attitude to social media and mobile devices

They have all mobile phones. Thirty percents of answerers have 3g-phone, 52,50% doesn't have and 17,50 percents doesn't know if their phone was 3g!



About 28% of these students have a profile in some social network in Internet (like Facebook). They are not so interested about blogs, but the Wikipedia is an quite important information source for them.

Factor analysis for background variables

Loadings:

	Factor1	Factor2
blogitkiinnostaa	-0.268	

ircgalleriakiinnosta	-0.316	
kannyero	0.271	
matematiikkavarma	0.824	
matikkakiinnostaa	0.230	0.940
matikkatarkeaa	0.294	0.783
mese	0.350	-0.153
mobiliikiinnostaa	0.802	0.230
tietokoneetkiinnosta	0.826	0.250
tietokonevarma	0.827	0.145
tietotekniikkatarkea	0.633	0.309
wikitarkea	0.315	0.212

	Factor1	Factor2	
SS	loadings	2.859	2.647
Proportion	Var	0.238	0.221
Cumulative	Var	0.238	0.459

Test of the hypothesis that 2 factors are sufficient.

The chi square statistic is 68.41 on 43 degrees of freedom.

The p-value is 0.00814

Factor1 loads : “In my opinion mobile devices are interesting”, “In my opinion computers are interesting”, “I feel myself confident when I work with computer”, “ In my opinion IT knowhow is important” and “When I do mathematical tasks I feel myself usually confident”.

Factor2 loads: “In my opinion mathematics is interesting” and “ In my opinion mathematical knowhow is important”.

Factor1 could be named “interest to technology”. Factor2 could be named “interest to content”. It is interesting, that you can’t find factor “interest to social media”. Maybe the role of social media is not so big as thank.

8.3.8. Technical problems with MMS

I got about messages to my phone as readable and listenable		
all	9	22.50%
none	19	47.50%
part of messages	12	30.00%

Some informal feedback:

“I don’t have operators MMS-settings.” (4 pieces)

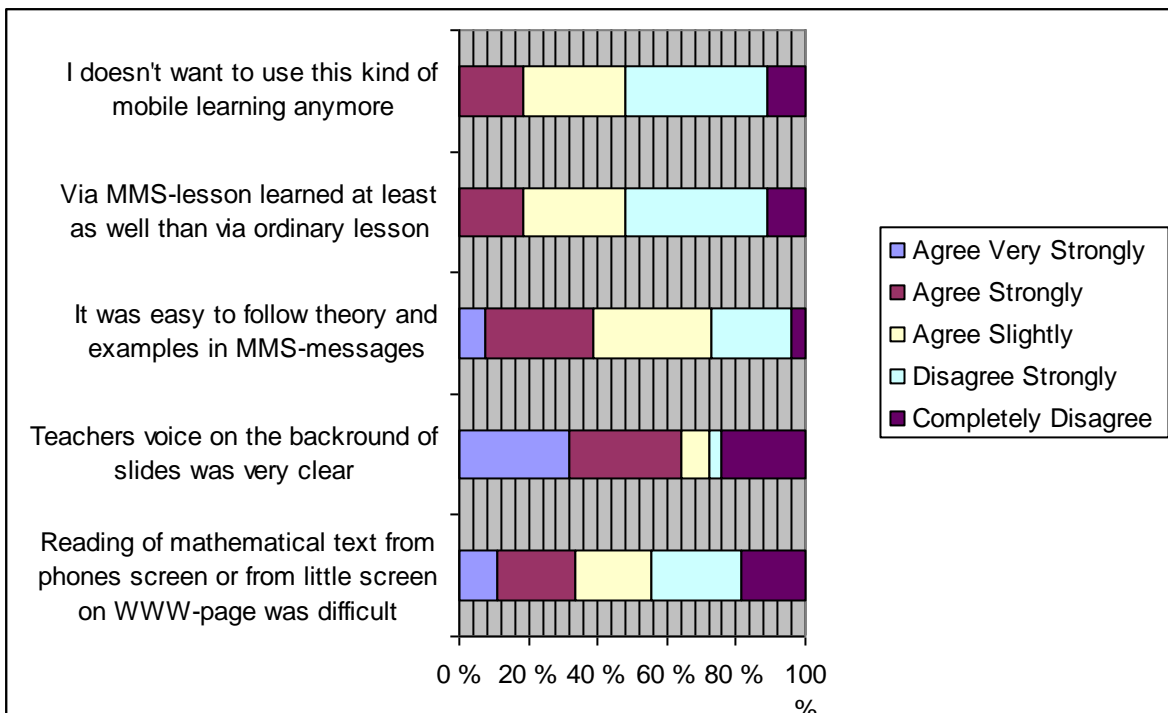
“I don’t hear voice of message.” (5 pieces)

“Text was too little.” (6 pieces)

“I got message, that you have got MMS-message and you can read it form operators WWW-page.” (1 piece)

17.50% of answerers was able to move messages to phone with cable or Bluetooth.

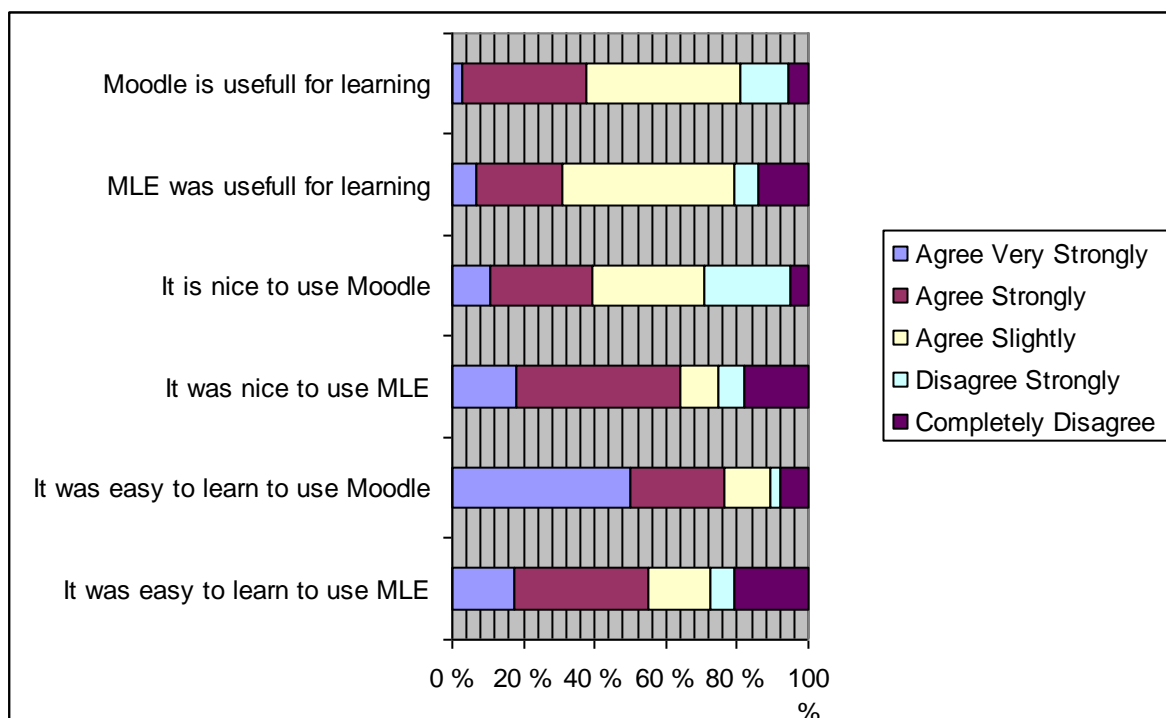
8.3.9. Main results



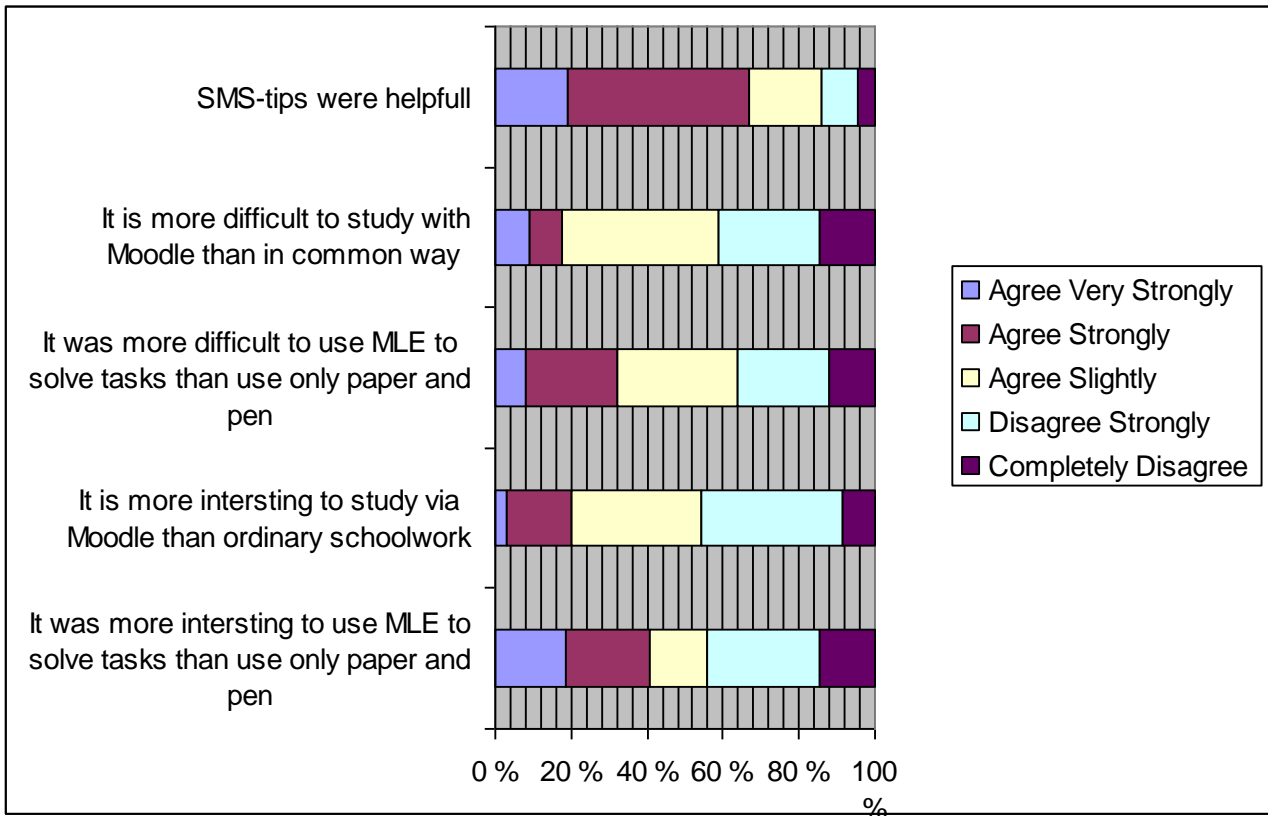
About 65 % students which have used MLE want to use it again. It is very good result; even though we have some technical and practical problems in this experiment. Mobile learning has some future! Students don't believe that learning results are as good as if we have used ordinary teaching methods. 27 % of students feel that slideshow was not good format for lesson because they had difficulties with following theory and examples.

Small screen on phones is not so big problem in mobile learning; 33 % of students have problems with small screen (agree very strongly or agree strongly). 64 % of students hear teachers voice clearly on MMS-message. It is easy to get better sound with better audio format, but it makes size of message bigger. Microphone I used to record my voice was not so good; it was my laptops microphone, so with better equipment can be reached better voice quality.

8.3.10. Comparison between the student's attitudes to the traditional web learning environment Moodle and the new mobile learning environment MLE



It was easier to learn to use Moodle (mean=1.92, sd=1.22) than MLE (mean=2.76, sd=1.41), but even that about 64 % of users of MLE felt that it was nice to use MLE (agree very strongly or strongly). There was not big difference between usefulness of these environments (Moodle: mean=2.84, sd=0.90 and MLE: mean=3.0 , sd= 1.1).



Students feel that it was slightly difficult to use MLE than Moodle (versus ordinary tools, Moodle: mean=3.29, sd=1.11 and MLE: mean=3.08, sd=1.15), but it was little bit more interesting (versus ordinary way, Moodle: mean=3.31, sd=0.96 and MLE: median=3.00, sd=1.39). Students feel SMS-tips helpful.

8.3.11. Correlations

Pearson's product-moment correlation	t	df	p-value	alternative hypothesis: true correlation is not equal to 0, 95 percent confidence interval	cor
"No more" and "MLE useful"	-8.0373	27	1.23e-08	-0.9223906 -0.6837151	-0.8397833
"No more" and "MLE easy"	-7.8841	27	1.780e-08	-0.9199492 -0.6750347	-0.8349664
"Moodle useful" and	5.6675	34	2.329e-06	0.4778734	0.6969838

"Moodle future"				0.8344449	
"Moodle easy" and "Moodle future"	3.3698	35	0.001844	0.2035678 0.7057745	0.4949406
"Mobile interesting" and "MLE interesting"	2.0517	25	0.05081	-0.0004491906 0.6638705614	0.3796296
"Mobile interesting" and "MLE useful"	3.3275	27	0.002538	0.2153287 0.7563001	0.5392752
"Mobile interesting" and "MLE nice to use"	5.0572	26	2.89e-05	0.4490938 0.8531323	0.7041867

"No more" = "I doesn't want to use this kind of mobile learning anymore."

"MLE useful" = "MLE was useful for learning."

"Moodle useful" = "Moodle is useful for learning."

"Mobile interesting"="In my opinion mobile devices are interesting."

"Moodle easy" = "It was easy to learn to use Moodle."

"MLE easy" = "It was easy to learn to use MLE."

"Moodle future" = "I want to use Moodle in future"

"MLE interesting" = "It was more interesting to use MLE to solve tasks than use only paper and pen"

"MLE nice to use" = "It was nice to use MLE"

Students doesn't want to use mobile learning or Moodle if it doesn't help them to learn. Mobile learning doesn't have any self value to the students. It is also important to students, that mobile learning is easy to use.

8.3.12. Men and women

					Analysis of Variance Table, Welch Two Sample	
					Pr(>F)	t-test, p-value
Variable: Slearned_ok					0.003064	0.002982
	mean	sd	n	NA		
Mies	2.923077	0.7595545	13	7		
Nainen	3.928571	0.8287419	14	6		
Variable: Sfollow					0.0006786	0.0006832
	mean	sd	n	NA		
Mies	2.230769	0.8320503	13	7		
Nainen	3.461538	0.7762500	13	7		
Variable: Snew					0.05044	0.04936
	mean	sd	n	NA		
Mies	2.866667	0.9904304	15	5		
Nainen	3.571429	0.8516306	14	6		

Between men and women there was some interesting differences.

It was for men easier to follow theory and examples in MMS-messages (Sfollow).

Men were also more optimistic than woman that they learned

via MMS-lesson at least as well than via ordinary lesson (Slearned_ok) and that

mobile learning was good tool to learn new things (Snew).

8.3.13. Learning results

anova(.Anova) Analysis of Variance Table

Response: test

Df	Sum Sq	Mean Sq	F value	Pr(>F)
----	--------	---------	---------	--------


```
group 1 107.51 107.51 9.9172 0.002460 **
```

```
Residuals 66 715.49 10.84
```

```
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# means
```

```
    Birgit  Mobile
```

```
6.318182 3.630435
```

```
# std. deviations
```

```
    Birgit  Mobile
```

```
2.998196 3.421232
```

```
# counts
```

```
    Birgit  Mobile
```

```
22 46
```

There were test for group B (the sum of the arithmetic sequence) after mobile learning experiment. Comparison group ("Birgit", which has studied same area ordinary way) made same test. Maximum points in the test were 12. As in figure 2.2. you can see, learning results were much better in comparison group, even both mobile and comparison groups has quite same mean of math marks (7,84 and 8). We must remember, that some students in Mobile group have not studied the sum of the arithmetic sequence at all before test! If we take away form statistics students with zero points in the test, comparison group has mean 6.62 and mobile group has mean 5.76, so difference between means is not so big any more!

8.4. Tekstiviestit ja tiedotus lukiossa

8.4.1. Aiempaa tutkimusta

Nix, Russel ja Keegan ovat listanneet millaisiin tiedotustarpeisiin korkeakouluissa tarvitaan tekstiviestejä.(Nix 2006)

Koulun hallinnolla on tarve lähestyä opiskelijoita SMS-viestillä monissa tilanteissa. Aikataulut muuttuvat joskus nopeasti. Luentojen peruutus tilanteissa perinteinen posti ja jopa sähköposti on liian hidas. Tekstiviestejä voi käyttää myös tutorointiin ja arviointien aikatauluista ilmoittamiseen.

Korkeakouluopintojen keskeyttäminen on yleiseurooppalainen ongelma. Pohjoisirlantilainen Ulsterin yliopisto on menestyksellisesti leikannut opintojen keskeyttämisprosentteja lähettämällä tekstiviestejä riskiryhmässä oleville opiskelijoille. Opiskelijat eivät kokeneet tunkeilevina saamiaan ”Olemme pahoillamme että ette olleet tänään paikalla” viestejä, vaan arvostivat yliopiston henkilökohtaista lähestymistä.

Etäopetus on yleistä korkeakouluissa. Eteläafrikkalainen Pretorian yliopisto on käyttänyt menestyksekkäästi tekstiviestejä etäopiskelijoiden ohjaukseen ja opiskelijat ovat vastanneet suurelta osin ja lähes välittömästi saamaansa ohjaukseen.

Dublinilainen teknologiainstituutti Tallaght otti käyttöön tekstiviestit opintojen ohjauksessa ensimmäisen vuoden opiskelijoille. Aiemmin oli käytetty tähän tarkoitukseen sähköpostia, mutta huomattiin, että opiskelijat eivät lukeneet oppilaitoksen tarjoamia sähköpostiosoitteita säännöllisesti ja näin ollen tärkeät tiedotukset luettiin liian myöhään.

Instituutissa kehitettiin Microsoft Outlookin sisään SMS-työkalu. Opettajat ja tukihenkilöstö voivat lähettää tekstiviestejä yksittäiselle opiskelijalle, opiskelijaryhmälle tai kaikille ensimmäisen vuosikurssin insinööriopiskelijoille. Opiskelijatiedot saatiin Excel-tietokannasta.

Tallaght:ssa käytettiin tekstiviestejä mm. seuraavanlaisiin tarkoituksiin:

- aikataulumuutokset ja luentoperuutukset
- luentosalimuutokset
- muistutuksia tenttiajoista
- muistutuksia kurssitöiden palautusajoista
- tietoja tenttitulosten ilmestymisestä tiedotustaululle
- tärkeiden tapahtumien ja opinto-ohjaus aikojen ilmoittaminen

Tallaght:ssa on tekstiviestitiedotus todettu arvokkaaksi lisäksi akateemiseen ympäristöön yksinkertaisuutensa ja tehokkuutensa vuoksi.

Massatekstiviesteissä saattaa joissakin maissa olla lainopillisia ongelmia. Jopa 5000 euron korvaussummia per tilaamaton viesti on määrätty oikeusistuimissa! Siksi suositellaankin kirjallisen SMS-tiedotusluvan ottamista opiskelijoilta.

8.4.2. Tarve Suomen lukioissa

Suomalaisissa lukioissa on aivan samantyyppisiä viestinnällisiä tarpeita kuin edellä on kuvattu. Keskusradiolla ei voida kaikkea tiedotusta hoitaa, sillä se ei tavoita varmasti kaikkia oppilaita. Onhan oppilailla hyppytunteja, jolloin he eivät välttämättä ole kuulemassa tiedotusta. Nelivuotisen opinto-ohjelman valinneet oppilaat ovat koulussa vain parikin tuntia päivässä ja juuri heille on usein koululla asiaa. Lisäksi keskusradiolla ei ole luontevaa kuuluttaa vain yhtä tai muutamaa oppilasta koskevaa asiaa. Luokattomassa lukiossa oppilaiden opettajat ja ryhmät vaihtuvat kuuden viikon välein, joten oppilaan etsimisessä koulusta on oma työnsä. Silloin on houkutteleva mahdollisuus käyttää täsmäviestimistä suoraan oppilaan ”taskuun”, varsinkin kun viesti tulee varmasti perille ja vielä välittömästi luetuksi.

Tekstiviestit ovat nousseet esiin myös valitettavasti Suomessakin lisääntyneen kriisitiedotustarpeen mukana. Vaikka kriisi ei koskisikaan omaa koulua, tarvitsevat oppilaat tukea vaikeiden asioiden käsittelyyn, jolloin tarjolla olevasta kriisiavusta pitää voida tiedottaa nopeasti ja kattavasti. Nopeaa tiedotusta tarvitaan myös huhujen kitkemiseen.

8.4.3 Konstruktio ja sen käyttö

Lempäälän lukiossa on kolmen vuoden ajan käytetty lukossa itse rakennettua tekstiviestijärjestelmää tiedottamiseen. Järjestelmä muodostuu tavallisesta matkapuhelimesta, joka on kytketty kaapelilla Linux-palvelimeen. Palvelin käyttää viestien lähettämiseen avoimen lähdekoodin Kannel-ohjelmistoa. Palvelin on näkyvässä julkisessa Internet-verkossa, joten opettajat voivat käyttää sitä viestien lähettämiseen myös kotoaan käsin. Viestien lähettäminen tapahtuu WWW-sivun kautta, josta voi valita rastittamalla oppilaat joille viesti lähetetään. Oppilaiden nimet ja puhelinnumerot on talletettu tietokantaan. Opettaja voi lähettää oppilaille viestejä myös ohjausryhmittäin tai muodostaa oppilaista itse pysyviä ryhmiä, joille voi lähettää viestin nopeasti. Järjestelmää voi käyttää myös tilanteissa, joissa viestissä on kaikille yhteinen osuus sekä kullekin oppilaalle oma osuus, kuten käyttäjätunnusten ja salasanojen jakamiseen tai ohjausaikojen jakamiseen.

Järjestelmä on alun perin rakennettu pedagogiseen opetuskäyttöön, mutta sivutuotteena on saatu myös toimiva tiedotusjärjestelmä. (Setälä 2005,2006,2009)

Nix, Russel ja Keegan raportoivat myös vastaavanlaisten kotikutoisten järjestelmien menestyksekkästä käytöstä (Nix 2006). Vaihtoehtona on palvelun hankkiminen joltakin ulkoiselta palveluntarjoajalta, mutta viestikohtaiset kustannukset voivat silloin olla suurempia verrattuna itse rakennettuun järjestelmään.

8.4.4 Tutkimusongelmat

Lempäälän lukion n. 330 oppilaalle ja opettajille suunnattiin kysely liittyen tekstiviestitiedotukseen. Haluttiin selvittää mm.

- a) Millaisia asioista viestejä oppilaille lähetettiin?
- b) Miten oppilaat kokevat tekstiviestitiedotuksen?
- c) Mikä on tekstiviestitiedotuksen nopeusero verrattuna sähköpostin, koulun kotisivujen tai Wilma-järjestelmän käyttämiseen? (Wilma on WWW-liittymä Primus-kouluhallintojärjestelmään: <http://www.starsoft.fi/public/?q=fi/node/64>)
- d) Miten järjestelmä helpottaa opettajan työtä?

8.4.5 Opettajakysely

Tekstiviestijärjestelmää oli käyttänyt seitsemän opettajaa koulun 28:a opettajasta. Lisäksi tämän tutkimuksen tekijä oli luonnollisesti käyttänyt tekstiviestejä tiedottamiseen. Seitsemästä opettajasta kuusi piti väitteitä järjestelmän ”käyttöliittymää on helppokäyttöinen” ja ”viestijärjestelmä on toiminut

luotettavasti viimeisen puolen vuoden aikana” hyvin tai erittäin hyvin paikkansa pitävänä. Kaikille vastaajille oli tärkeää, että viestejä pystyi lähettämään myös kotoa käsin. Opettajille ei ollut ongelma viestien rajoitettu merkkimäärä. Siitä huolimatta he olivat mielestään saaneet lähetettyä selkeitä viestejä. Kuusi vastaaja näistä seitsemästä oli sitä mieltä, että oppilaat olivat suhtautuneet positiivisesti tekstiviestitiedotukseen. Jos tekstiviestit voisi jatkossa lähettää Wilma-järjestelmän kautta, se lisäisi joidenkin opettajien kohdalla viestien lähettämistä.

Opettajat olivat käyttäneet järjestelmää seuraaventyyppisten viestien lähettämiseen:

- uusintakokeiden osallistumisoikeuksista
- tenttijärjestelyistä
- tekemättömistä töistä / puuttuvista suorituksista
- rahankeruuasioista
- ryhmänohjauksen haastatteluajoista
- itsenäisistä suorituksista
- verkko-materiaaleista
- yhteydenottopyyntöjä
- oppituntien peruutukset, aikataulumuutokset, luokkatilamuutokset
- muistutuksia tapahtumista
- ”jos on paljon asiaa ja nopeasti, voin infota tyyliin zekkaa maili”

Opettajien mukaan SMS-järjestelmä on helpottanut seuraavilla tavoilla heidän työtään:

- oppilaan saa varmemmin kiinni kuin Wilmaa tai sähköpostia käyttämällä
- mahdollisuus saada lyhyelläkin varoitusajalla viesti oppilaalle
- ei tarvitse lähettää omaan laskuun tekstiviestejä, viestin kirjoittaminen tietokoneelta on helpompaa kuin kännykästä
- tekstiviestistä jää opettajalle dokumentti, toisin kuin puhelinsoitosta
- omassa kännykässä ei tarvitse pitää oppilaiden yhteystietoja, kun viestin voi lähettää verkosta

8.4.6 Opiskelijakysely

Opiskelijoista 21 % vastaa, että ei lue sähköpostiansa päivittäin. Opiskelijoista 95 % lukee saamansa tekstiviestit useimmiten välittömästi.

Kysymykseen ”Kuinka monta kertaa päivässä luet sähköpostisi?” saatiin taas seuraavanlainen vastausjakauma:

Vastaus Prosenttiosuus

0 13.39%

1 46.43%

2 20.54%

3 8.04%

4 2.68%

5 2.68%

6 tai enem. 6.25%

Kysymykseen ”Koulun tai opettajan lähettämä tekstiviesti tunkeutuu liikaa henkilökohtaiselle alueelleni” saatiin asteikolla

1) pitää erittäin hyvin paikkansa

2) pitää hyvin paikkansa

3) pitää jossakin määrin paikkansa

4) ei juurikaan pidä paikkaansa

5) ei ollenkaan pidä paikkaansa

seuraavanlainen jakauma

Vastaus Prosenttiosuus

1 6.25%

2 5.36%

3 9.82%

4 25.00%

5 53.57%

Kysymykseen ”Koulun tai opettajan lähettämät tekstiviestit ovat lyhydestään huolimatta olleet ymmärrettäviä” saatiin jakauma

Vastaus Prosenttiosuus

1	46.43%
2	33.04%
3	9.82%
4	4.46%
5	6.25%

Kysymykseen ”Koulun ja opettajien pitäisi käyttää enemmän tekstiviestejä tiedottamisessa oppilaille” muodostui jakauma

Vastaus Prosenttiosuus

1	14.29%
2	16.96%
3	39.29%
4	23.21%
5	6.25%

Kysymykseen ”Opettajien pitäisi käyttää enemmän Wilmaa tai sähköpostia viestinnässä oppilaille” tuli jakauma

Vastaus Prosenttiosuus

1	16.96%
2	37.50%
3	30.36%
4	8.93%
5	6.25%

Kysymykseen ”Koulun pitäisi käyttää tekstiviestejä vain kiireellisissä viesteissä ” tuli jakauma

1	11.61%
2	15.18%
3	41.07%
4	26.79%
5	5.36%

Kuinka monesti viikossa käyt Lelun kotisivuilla

Vastaus Prosenttiosuus

0	17.86%
1	33.93%
2	25.00%
3	10.71%
4	6.25%
5	4.46%
6 tai enem.	1.79%

Vapaassa palautteessa oli muutama mielenkiintoinen ajatus:

”Minusta kaiken siirtyminen virtuaaliseksi painostaa oppilasta käymään koneella joka päivä. Kaikki eivät käytä konetta, jolloin tärkeät asiat menevät ohi, koska niistä informoidaan vain netissä tms. Se on mielestäni epätasa-arvon muoto.”

” Wilma ja tekstiviestit ovat hyvä tapa informoida oppilaita, kunhan ne toimivat ja niitä käytetään, oikein. Tekstiviestiä koulusta ei kuitenkaan ole mukava saada iltamyöhään tai viikonloppuisin, ellei kyseessä ole todella kiireellinen asia. Arkipäivinä tiedotus kullekin tekstiviestillä on mielestäni hyvä ja toimiva asia, kunhan se toimii...”

8.4.7 Tilastollista analyysiä

Varianssianalyysiä

Miesten ja naisten välillä ei juurikaan ollut eroja vastauksissa. Alla kaksi esimerkkiä.

Variable: "Koulun ja opettajien pitäisi käyttää enemmän tekstiviestejä tiedottamisessa oppilaille"

mean sd n NA

Mies 2.821429 1.161616 56 0

Nainen 2.722892 1.129572 83 0

Variable: "Koulun tai opettajan lähettämä tekstiviesti tunkeutuu liikaa henkilökohtaiselle alueelleni"

mean sd n NA

Mies 4.178571 1.129878 56 0

Nainen 4.120482 1.262958 83 0

Varianssianalysissä löytyi vain yksi tilastollisesti edes oireellinen tulos, joka liittyi Wilman käyttämiseen poissaoloseurantaan. Yllättäen pojat suhtautuivat positiivisemmin sähköiseen poissaolojen seurantajärjestelmään:

```
> summary(AnovaModel.4)
Df Sum Sq Mean Sq F value Pr(>F)
Sukupuoli 1 5.843 5.843 3.0969 0.08068 .
Residuals 137 258.502 1.887
```

Signif. codes: 0 '****' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

mean sd n

Mies 2.196429 1.406732 56

Nainen 2.614458 1.350983 83

Oppilaiden iällä ei ollut myöskään suurtakaan vaikutusta vastauksissa.

Korrelaatioanalyysiä

Luonnollisesti sähköpostin ja tekstiviestien tunkeilevaksi kokeminen korreloivat keskenään voimakkaasti:

```
Pearson's product-moment correlation
data: SMS$meilialueelleni and SMS$smsalueelleni
t = 19.5314, df = 137, p-value < 2.2e-16
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
0.8064414 0.8962644
sample estimates:
cor
0.8577671
```

Kysymyksellä "Pidän lukio-opiskelusta" mitattiin oppilaiden yleistä suhtautumista lukioopiskeluun.

Tämä muuttuja ei suurestikkaan korreloinut oppilaiden viestinnällisten

asenteiden kanssa. Esimerkiksi tekstiviestien tunkeilevaksi kokeminen selittyi vain

n.25%:sti sillä, miten oppilas koki lukio-opiskelun.

```
Pearson's product-moment correlation
data: SMS$meilialueelleni and SMS$pidanlukio
t = -6.5948, df = 137, p-value = 8.523e-10
```


alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
-0.6077084 -0.3532469
sample estimates:
cor
-0.4908764

8.4.8 Johtopäätökset

Tekstiviestit sopivat pääsääntöisesti sekä oppilaiden että opettajien mielestä hyvin tiedottamiseen. Tekstiviestit ovat sähköpostia varmempi ja nopeampi tiedotuskanava kiireellisissä viesteissä, sillä kaikki eivät lue sähköpostia päivittäin. Tosin noin 30 % oppilaista suhtautuu varauksellisesti tekstiviestien käytön lisäämiseen ja toivoo että niitä käytettäisiin vain kiireellisissä tapauksissa. Noin kymmenen prosenttia oppilaista kokee, että tekstiviesti tunkeutuu liikaa heidän henkilökohtaiselle alueelleen. On todennäköistä, että tekstiviestien käyttö tulee lisääntymään nopeasti lukioiden tiedotuksessa oppilaille, kun ne integroituvat verkkoviestintäjärjestelmiin, kuten Wilmaan. Keskitetyt verkkoviestintäjärjestelmät tulevat olemaan tulevaisuudessa tärkeä osa modernin lukion infrastruktuuria.

Viitteet

Nix, J., Russell, J. and Keegan, D. 2006: Mobile learning/SMS (Short Messaging System) academic administration kit <http://www.eden-online.org/contents/publications/SMS/Ericsson.Mobile.A5.pdf>

Setälä, M. 2005. Oppimisen mobiili ulottuvuus yleissivistävässä koulutuksessa – Teknologinen näkökulma” joka on julkaistu ”Interaktiivinen tekniikka koulutuksessa 2005 –konferenssin tutkijatapaamisen artikkelit” – julkaisussa, joka on luettavissa osoitteesta <http://tampub.uta.fi/tup/951-44-6515-6.pdf>

Setälä, M. 2006. “Oppimisen mobiili ulottuvuus yleissivistävässä koulutuksessa: teknologinen ja pedagoginen näkökulma” joka on julkaistu ”Interaktiivinen tekniikka koulutuksessa 2006 – konferenssin tutkijatapaamisen artikkelit” – julkaisussa, joka on luettavissa osoitteesta <http://tampub.uta.fi/tup/951-44-6822-8.pdf>

Setälä, M. 2006. Mobile Learning - from Hardware to Pedagogy. Proceedings of the Workshop on Human Centered Technology HCT06, Read: <http://amc.pori.tut.fi/hct06/hct06proceedings.pdf>

Setälä, M. 2009. MMS-messages on the teaching of mathematics. IADIS International Conference

Mobile Learning 2009. Barcelona, Spain.

9. The fourth cycle: Binder-Opit

9.1 Moop

Moop is a mobile learning environment developed by the software house Incode Oy (from Oulu Finland) especially for situations where primary school pupils use a mobile phone to analyze their surroundings and to communicate within groups. A pupil makes observations and saves and manages information in the mobile and network learning platform. The traditional learning environment is broadened from classroom to observation in the surroundings. The goal is to increase interactivity and collaboration in learning with the help of a mobile phone. In the Moop environment the mobile learning is realized through tasks based on geographical location and requiring creative problem solving. (Mattila 2005)

The basic ideas at the background of Moop are school curriculum and content of education, pupils as users of technology, collaboration with parents and school, cooperation between the schools, breaking the boundaries between the classrooms and developing the pedagogy. The main purpose for the school is to provide basic education. With ICT-technologies we can give support to the pupils learning process. Mobile learning environment has to adapt as a natural part of the daily schoolwork and pupils class schedule. (Mattila 2005) So Moop project doesn't see mobile learning as distinct section in schools, but wants to integrate it to ordinary school work and curriculum.

In the Moop-project it has been designed a user interface and application working for mobile devices in Symbian S60 operating system. It includes an observation gallery, a user interface for management of users and map bases as well as some administrative tools in the Moop-network environment. Moop-observations are utilized as a part of web-based learning environment Riihi. (Mattila 2005)

In the first phase was created a platform for collecting data from near surroundings. It enables the observation, saving and sending of phenomenon with the location information (GPS-data) from observation point straight to the server by using data connection (GPRS/3G). The media transmitted through user interface can be text, photo, video (3gp file), a report, a record or transcription like voice message, for example an interview (amr file). Platform enables the edition and analysis of raw data instantly in the observation point. Pupils login with their own usernames to the MOOP-environment. The mobile terminal is in connection with a server program which transmits the information between mobile terminals, www-browser and data base. (Mattila 2005)

In the second phase into the environment has been developed a possibility to build task courses, which enables to form location-bound routes. The returning time and the safety area will be defined into the each route. Also tools was build for helping to enlarge the cooperation and interaction as Push to talk function and reading and answering messages inside the Moop. (Mattila 2005)

Both the teacher and the pupil have a camera phone using the Symbian operating system. The learning tasks are being transmitted through the Moop-application. The class teacher guides the action by setting questions and pupil does the observation and problem solving in a meaningful way from the surroundings. With GPS-locator the pupil is able to find his own position and the observations taken from the map base. The location information will automatically be attached to every observation and will be transferred to the class room to the school teaching situation. There are more web-based tools (Riihi) to handle and perform the observations in the classroom. The information stored with mobile devices is categorised and specified through logical user interface. The meaning of that information is to fulfill the information found from the study book, as a natural part of school's learning process and curriculum. (Mattila 2005)

Pupils have also in their use Moop-network environment, where they sign in with the same username as to their mobile device. The observations made by camera phone are transferred to the network, where those are available to the pupils in their computer or laptop. The pupils operate by using tools on a Moop-network environment or the used web-based learning environment (Riihi). The observations are listed according to observation group or shooting date. Writing notes can be added as well. The meaning of these messages is to analyze pupils work and thoughts when writing the final outcome. (Mattila 2005)

The teacher has also administrative tools, which give the teacher wider opportunities, such as run and edit tasks. Admin user has a right to create maps and the location points needed for the GPS-locating. Admin user can plan routes and tasks to the pupils and for their mobile devices. Teacher can remove the pointless observations and also publish good quality works or pupils' material in the bank, from where it can be utilized by the others. Teacher can also transfer the photo straight to the web-based learning environment (Riihi). (Mattila 2005)

Moop is based on the idea where the application collects useful features (a camera, a video camera, a voice recorder and GPS-locator) from mobile phone inside the one user interface. The additional information like the shooting time, date, place and the photographer is being recorded. Before the application sends the observation further it must be named or classified by typing. The function is for the analyzing the observation purposes straight from the shooting point. It guides to consider more closely the circumstances in the place the observation is made and this information is useful when the learner is building the final study in the classroom situation. (Mattila 2005)

Maps are at the server and are downloaded to the user's mobile phone via data connection and GPS-positioning system. Before utilization the map has to be transformed into a suitable form and scale. A location-bound task course is created with the help of a GPS-locator and a user can easily proceed on course. The defined boundaries limit access to safe and permitted routes only. If a pupil leaves the defined safety area, both the pupils' and teachers' mobile phone notifies them with a voice signal. Planning the route with Moop's map view gives the possibility to plan a variety of learning situations and study plans. With the teacher application it is possible to plan the route directly live on course in the nature and in the observation place. (Mattila 2005)

PoC enables a direct voice communication between teacher and / or pupils in a closed environment. The Poc connection is opened with a push of a key (tangent), just like in the old radio phones. PoC connection establishes security. In remote learning situation the teacher or peer group can be activated by pressing just one button. By using the PoC connection it is easy to direct group movements and to give extra information which can be helpful when seeking the solution to a task. It is also realistic to give all introductions through Push to talk connection. This direct call over data connection improves the usage of environment by giving remarkable additional feature to interaction and cooperation tools in the Moop. The interaction between learners can be also supported by the tools for send and read messages. (Mattila 2005)

The pedagogical principles in Moop project are: inquiry learning, skills for gathering information and building knowledge, creative problem solving and leading to the interactive and cooperative learning. (Mattila 2005)

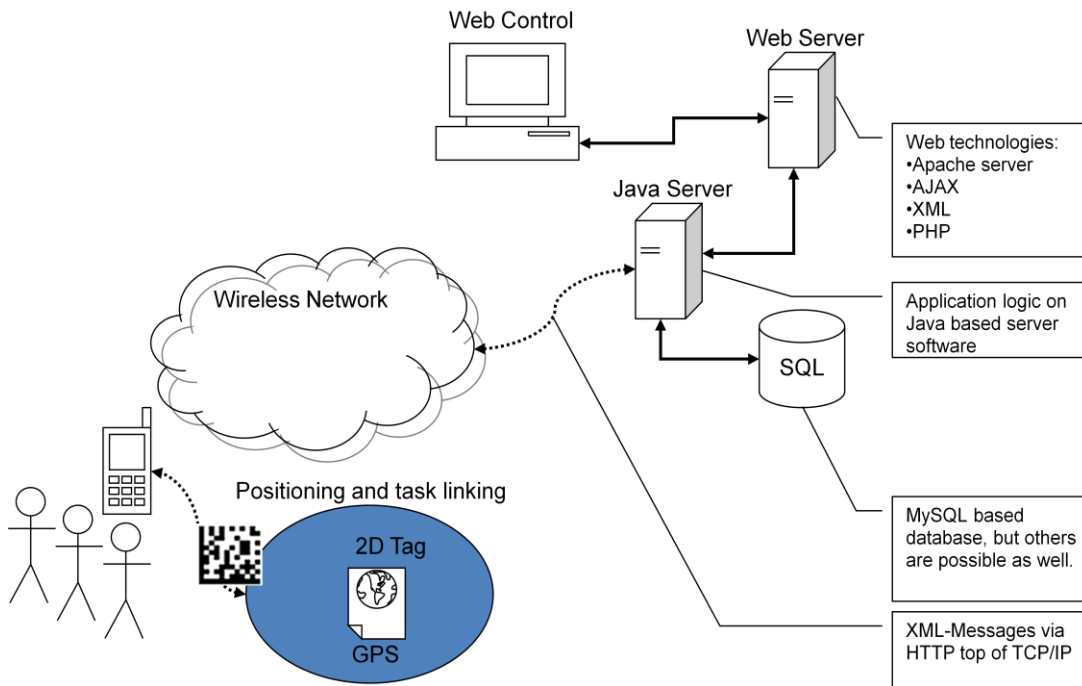


Figure1 from <http://webanet.ucs.fi/webanet/brieftec-binder-mobiilisovellus/>

In figure 1 there is chart of technology used in Moop system.

9.2 Binder and Opit

Brieftecy Ltd. commercialized Moop environment with name Binder. The Brieftecy Binder mobile and web based learning environment, was launched into the market 2006. It has received international recognition by receiving the Microsoft Worldwide Innovative Teachers Award 2006 - in the community innovation category.

In 2008 Brieftecy started co-operation with Wsoy Opit. Wsoy is the main publisher of learning material in Finland. 'Opit' is a ICT-based (web-based) full-service learning environment by WSOY. Schools around Finland use it and in 2008 the total amount of users was over 150 000 (Laakso 2010).

Opit is designed for supporting collaborative pedagogical practices in schools. It includes several tools for this purpose: a discussion forum, personal and shared (group) portfolio files, project management tools and lots of learning objects related to the subjects of curriculum of Finnish comprehensive and secondary school.(Ryymin 2008)

In Brieftecy Binder web environment teacher can make tasks, routes and manage observations made by pupils. Observations include photo or video taking by pupil, shooting time and place on the map (Google Maps). In the web environment it is also possible to share observations in the social media like Facebook. In Opit learning environment it is possible upload observations from Binder web environment and so add them for example to Opit discussion forum.

Lempäälä municipality bought Opit Binder service for two years. This service included 6 Nokia phones with Binder java application installed and 3G data connection included, Brieftecy Binder web environment and

Opi learning environment. The price of the system was high, but we got 70 % state subsidies from learning environment project of The Finnish National Board of Education.

9.3. Case 1: forestry education task course

I tested first time Opi Binder on spring 2009 with Teemu Nieminen's 5 th grade pupils on Sääksjärvi primary school. Near the school there is ready forestry education task course with pathway, control points and tasks. We make some edition to tasks. The length of pathway is one kilometer and original tasks are made by The Finnish Regional Forestry Network and Game Management District.

9.3.1. Making of the tasks and courses

I first explored course on the map and checked ready tasks. I made safety area round the pathway. Then I went to the forest and with mobile phone application and GPS and I made control points to the pathway. It is impossible to made control points with network map solution with computer, because it cannot be done exactly enough.

The ready tasks of forestry education task course were not useable, so teacher of class Teemu Nieminen made some changes to the tasks.

1. Take a photo from your group. Write your names to the paper.
2. Mosses: Look for three different types of moss. Take a photo and add a name of the moss to the photo. Please write in the paper "There are many mosses"
3. Growth places: Take the overall photo on the left and the right side of the path. Identify the most common tree on the each side. Why situation is different on the left and the right side of the path. Look and take a photo from the giant stone (boulder).
4. Warren: Why the ants are useful animals for wildlife? Write to the paper two reasons.
5. Fin: Seek the marsh tea and take a photo. Please write in the paper how the swamp trees look like and why.
6. Logging: Why are forests being harvested? Please answer to the paper.
7. Build a cone cow.
8. Watch for wildlife when your walks from this check point to the next one. Do you see a tree, which roots are on the surface of path. Answer to the paper.
9. How you should do, if you stray into the woods. Answer to the paper.

Long textual answers we decided to ask pupils wrote to the paper, but all questions come from mobile phone (with peep sound) when group was at check point controlled by GPS. There were four questions, where pupils take photos.

We found, that the biggest question with these kinds of mobile tasks is connecting to the curriculum. What happens in the class before and after mobile task course? The task course cannot be separate event without gripping surface to ordinary school work. When some observations are made on the course in the forest, how these can be exploited on the class work? There are not available ready pedagogical models. When this kind of system is sold to the school, these ready pedagogical models must be included to the commercial product. Without these models teacher uses mobile learning only once and says that "this was nice experiment but so what". Teachers don't get from teacher education capacity to make this kind of pedagogical models himself or we doesn't have time to make pedagogical planning needed. A lot of

pedagogical support and ready made learning objects are needed when starting mobile learning on ordinary schools. Opit Binder was not pedagogically commercialized as much should need.

Another big issue is how to develop mobile task courses evenly throughout the year. Fall and spring are a good time for the task courses, but how about winter? Is it so, that we must in the winter use mobile learning mainly indoor like in museums? Mobile hardware and software are, however, a big investment, so we should find enough use throughout the year.

9.3.2. Technology

Students became familiar with equipment and experimented use of mobile application before entering task course. This is necessary that pupils can concentrate to tasks, not use of technology, when they are in the forest.

Mobile learning technology is not so mature than ordinary computer technology. We have lots of hiccups with equipment. Mobile map from which pupil can watch on real time how he or she is walking in the forest was not accessible even if it is part of the functionality of system. So there was a bug in the system. This was not a big problem for us, because pathway was clearly marked on the woods. This functionality is imperative if course is not marked on the terrain.

When a pupil walked to the control point, a task was arrived to his or her phone with peep sound. Screen of the phone Nokia N70 was small and you cannot scroll the text on the application, so it was not possible to make quite complicated tasks which need a lot of text. It would be nice, if you can put pictures or speech to the task.

Some pupil's mobile phone application crashed down and it had to be restarted. I ran pathway back and forth to guide the students when problems came up. In this type of task courses it is good if technical support person is available to the students. Teacher cannot solve alone all technical problems encountered.

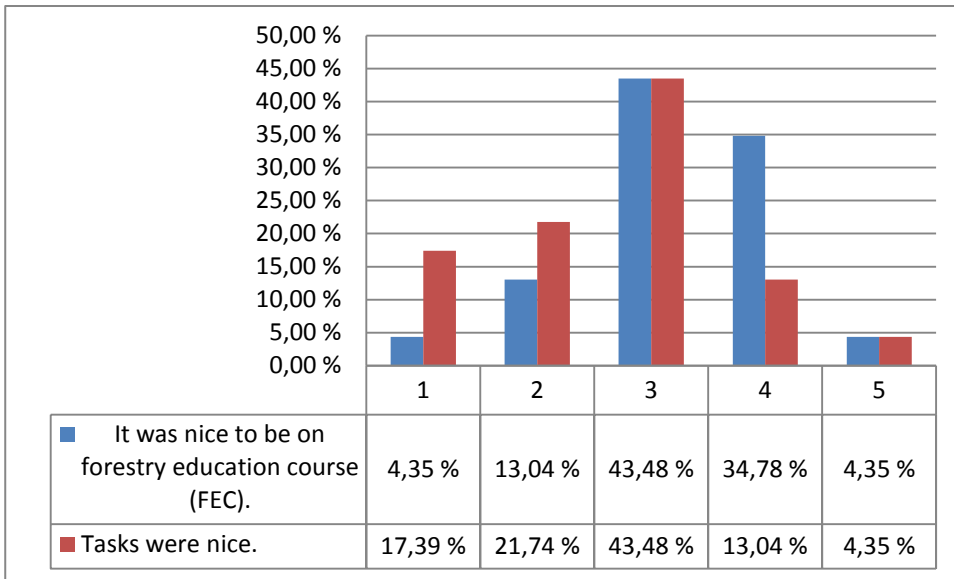
Nokia N70 did not have integrated GPS functionality, but using separate GPS device connected with Bluetooth to the phone. Management of two devices was not so easy for pupils, especially when phone must restarted and connection between phone and GPS device was not activated for some reason. This Nokia N70 was not best choice for Opit Binder device. It is not reasonable to use cheap old phone models in commercial mobile learning products.

We also found, that if check points are too close together, pupils can mix tasks. It would be good that distance between check points is at least 50 meters.

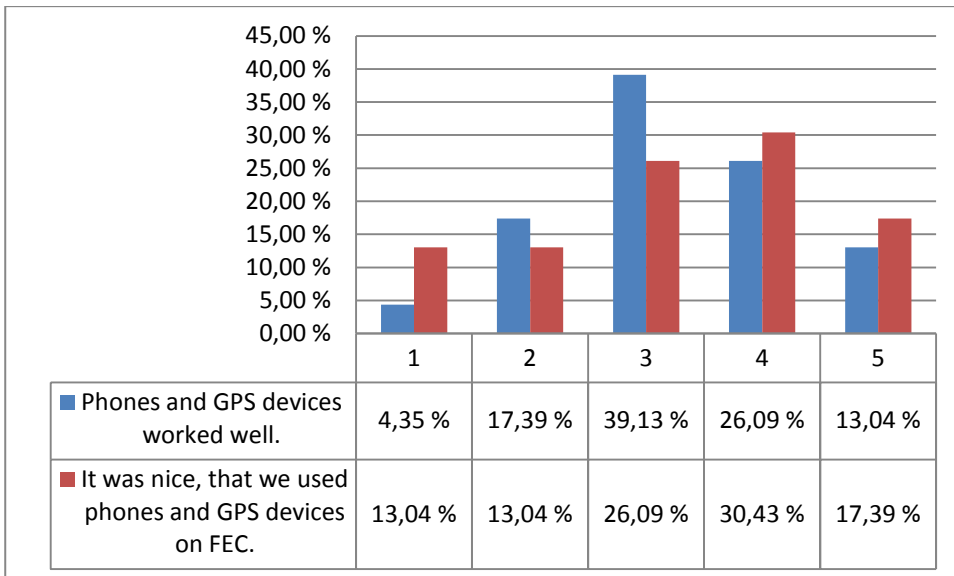
9.3.3 Survey for pupils

On the class there were 12 girls and 10 boys. They have all own mobile phone and all can use computer at home. We have only six mobile phones with application on the task course, so pupils made tasks in the groups. Nine of 22 pupils used Opit Binder on the pathway.

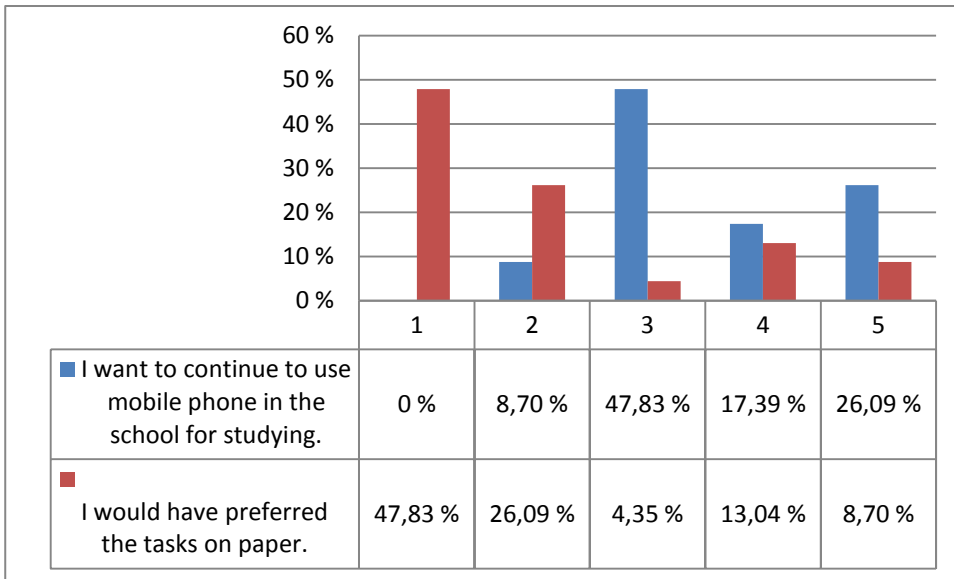
We used Likert scale in some questions : completely disagree (1), disagree strongly (2) , agree slightly (3), agree strongly (4) and agree very strongly (5).



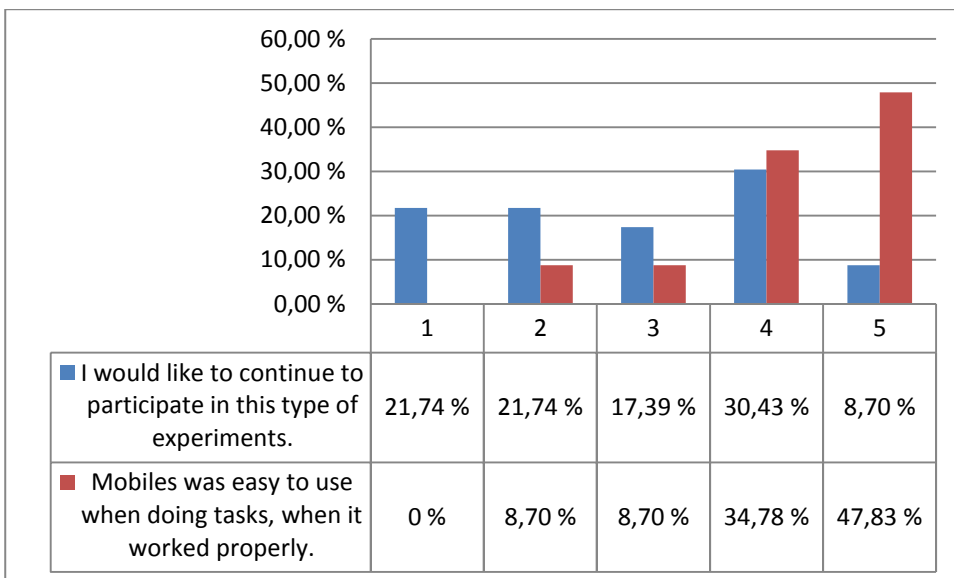
Pupils like to be on the forest, but tasks were not so nice.



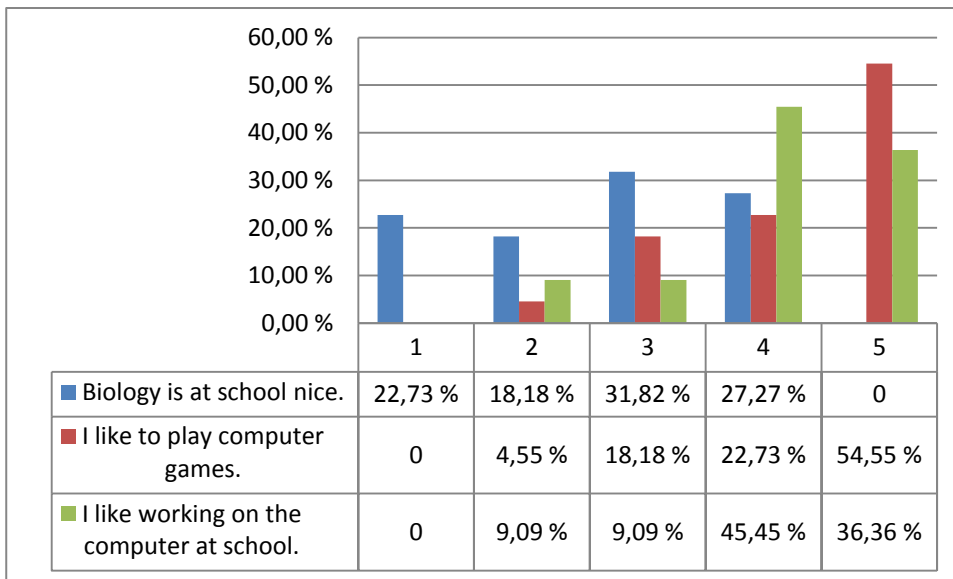
Pupils don't were so critical to technical problems met and they liked to use mobile technology.



Pupils want to use mobile technology to studying also in the future. Some pupils wanted to have tasks on paper, but not so many.



Forty percent of pupils don't want to take part this kind of experiments any more. Pupils found mobiles easy to use.



I used analysis of variance to all variables and found that girls want tasks on the paper more than boys. Maybe girls are more orientated to tasks than to technology. Result is only statistically almost significant.

```
> AnovaModel.1 <- aov(paperiparempi ~ Sukupuoli, data=M)
```

```
> summary(AnovaModel.1)
```

```
Df Sum Sq Mean Sq F value Pr(>F)
```

```
Sukupuoli 1 5.6379 5.6379 4.1278 0.05568 .
```

```
Residuals 20 27.3167 1.3658
```

```
---
```

```
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
> numSummary(M$paperiparempi, groups=M$Sukupuoli,
statistics=c("mean", "sd"))
```

```
mean sd n
```

```
Poika 1.400000 0.6992059 10
```

```
Tyttö 2.416667 1.4433757 12
```

Some correlations were calculated also.

Pearson's product-moment correlation

data: M\$bilsa and M\$polullakivaa

$t = 4.4928$, $df = 20$, $p\text{-value} = 0.0002224$

alternative hypothesis: true correlation is not equal to 0

95 percent confidence interval:

0.4094898 0.8702942

sample estimates:

cor

0.7087385

"It was nice to be on forestry education course" and "Biology is at school nice" correlated quite strongly with each other. 50% of the variability in "It was nice to be on forestry education course" can be explained by the variability on "Biology is at school nice". "It was nice to be on forestry education course" has not correlation with "I like to play computer games" and "I like working on the computer at school". Maybe we can think that for student's content is more important than technology.

Some open questions were put to pupils:

What on forestry education course was the nicest?

- "mobile phones when we do something with them"
- "taking pictures and walking on the woods"
- "tasks game from phones"
- "taking pictures of plants and all the stuff"

What was the most boring?

- "the equipment doesn't work, and that at every check point must be correcting"
- "when the cell phone did not work at some point"
- "return journey"
- "look for them to be pictured"
- "being in the woods"
- "mobile phone use"

What was the hardest with cell phone?

- "because it went from the place immediately away"
- "it did not work"
- "when it did not show the tasks, and sometimes it did not send pictures"
- "it does not always function properly"
- "GPS device start-up"
- "that it not shown task in the right place"
- "sending because sometimes it did not send it"

What was the hardest with cell phone?

- "taking a picture" (8 for the same answer)
- "well, then when it got to work so it worked pretty well"

9.3.4 Teacher's feedback

Teacher of class Teemu Nieminen give also some feedback:

Forestry educational path worked as general level well. Devices give motivation to the pupils. Positive was also that pupils could make functional task, which were however easy to the teacher to evaluate. It was important to try mobile application with pupils before going to the forest, so they can concentrate to the tasks. Technical support was important on the path, because there were many technical problems.

The rounding of the learning path went well after the initial difficulties. The students were enthusiastic and involved in co-operative learning. Many things about biology teaching contents was learned certainly better than if they had just studied the book. Writing tasks are cumbersome with phone, so it is better to use more sounds and images.

9.4. Case 2: Museum

The second Opit Binder experiment was autumn 2009. We got a new version of software, which we tested on museum education at Kuokkala museum road. We have also a new phone model Nokia 6220 Classics. The new version with this new phone model worked better. There were not so many technical hiccups, but some problems encountered anyway.

Because some check points were indoors and museum area was quite small, we do not used GPS but 2D-tags. We set tag near the task area and when pupil takes a photo from the tag the task about that area comes to the phone. If shooting of the tag does not worked, pupil can also give the number of the task and so get the right task.



Kauppa ennen ja nyt

/154/

Aleksanteri Eskola piti kauppaa vuosina 1913-1974. Miten kaupassa asiointi hänen aikanaan poikkesi asiointista esimerkiksi S-market Lempäälässä? Esitä erot ottamalla kuvia kauppamuseosta

Kuokkala Museum is a local history museum and its almost originally preserved yard has many little special museums: Shop Museum, Barber Museum, Shoemaker's Shop, Blacksmith's Workshop with a section for driving tools, War Veterans' Traditional Chamber as well as the Hut of Kustaa Puskema. The most notable of these is the Shop Museum. It's one of the oldest shops in Lempäälä, built in the beginning of the 20th century.

Tasks produce museum guides, and they were very successful pedagogically. Pictures here are from the pupils answers.

1. Trade, then and now.

Alexander Eskola was a trader in this shop 1913-1974. How shopping was different in his time compared to the S-market Lempäälä today? Show difference by taking pictures of the Shop Museum.



2. Barber.

How does development of the barber tools appears in then Barber Museum? Choose one of the tools and show its development by taking pictures of Barber Museum.



3. Shoemaker.

Your shoes are probably made in factory. In the past, however, shoes made by hand. If the shoemaker should be prepared your shoe, what kind of shoe manufacturing stages there should have been? Give the answer by taking pictures.



4. Rear veranda

The back porch is full of old household goods. Shoot one strange object, and invented a name for it and tell what the purpose of the object is.



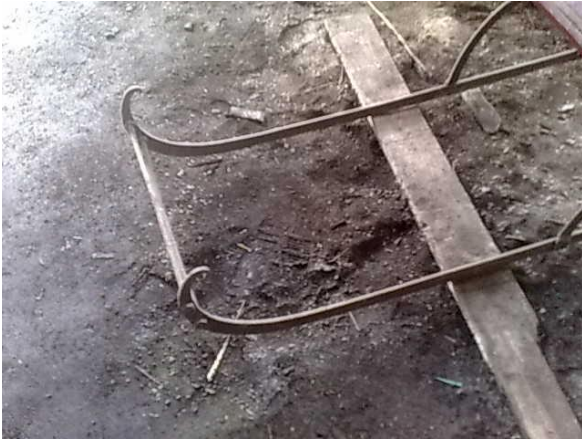
5. Chimneyless

Kustaa Puskema lived in this chimneyless in the turn of 1800-1900 and maintain himself as making of shoes. Shoot sequence, with at least five pictures of Kustaa's everyday life.



6. Smithy

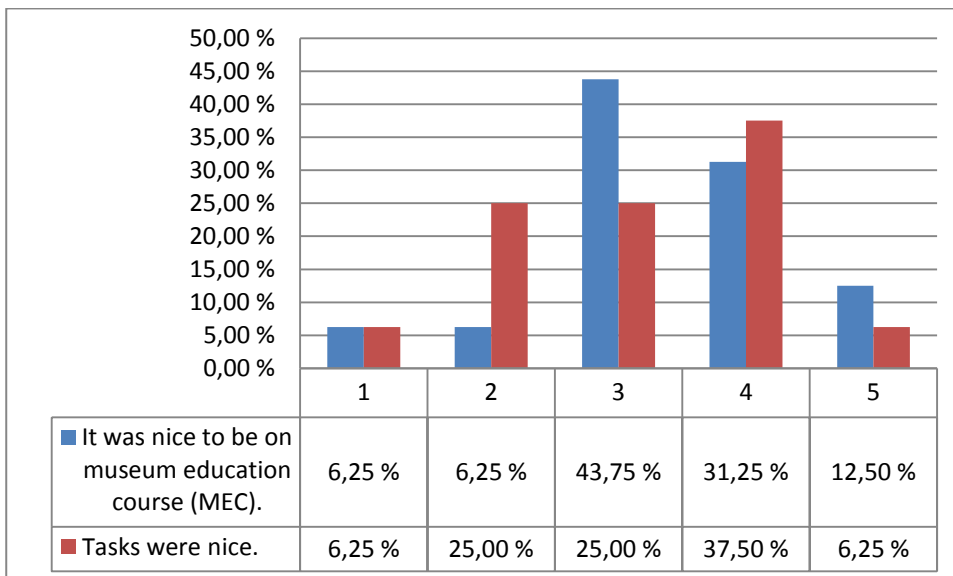
Smithy of K. A. Koskinen was completed in this place in 1910. What may have been manufactured in this smithy? Shoot for at least five pictures.



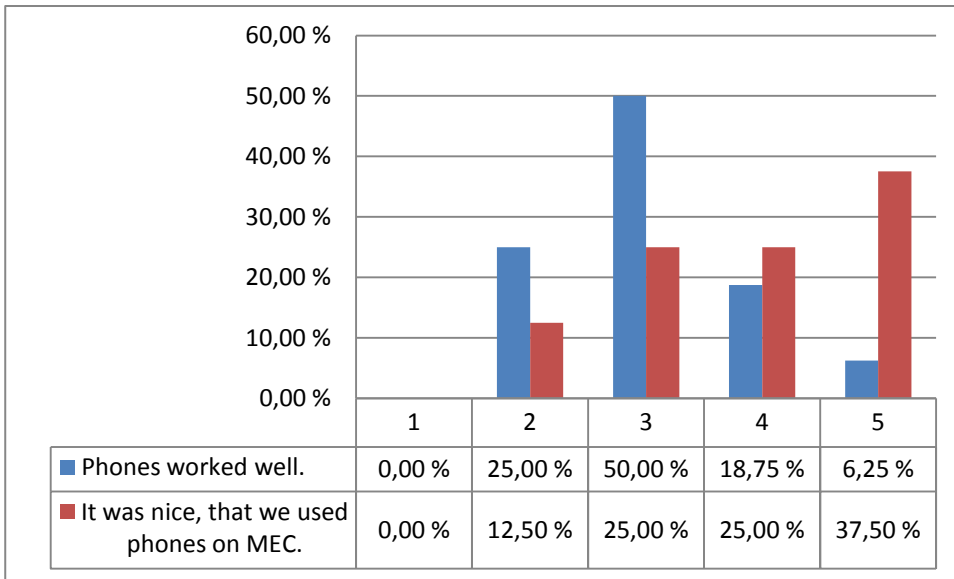
9.4.1 Survey for pupils

The pupils were from 5th grade.

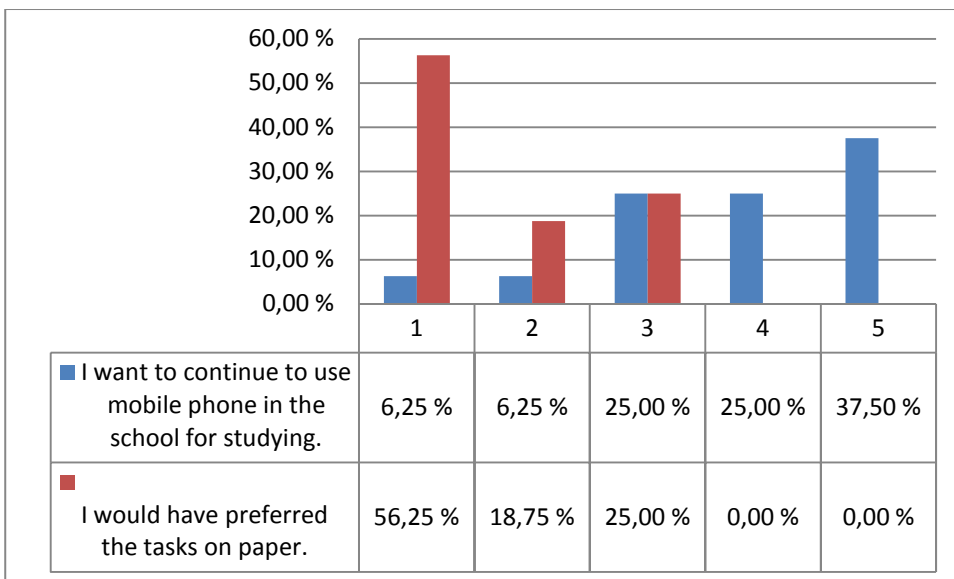
On the class there were 8 girls and 8 boys. They have all but one own mobile phone and all can use computer at home. We have only six mobile phones with application on the task course, so pupils made tasks in the groups. All pupils used Opit Binder application on the museum course.



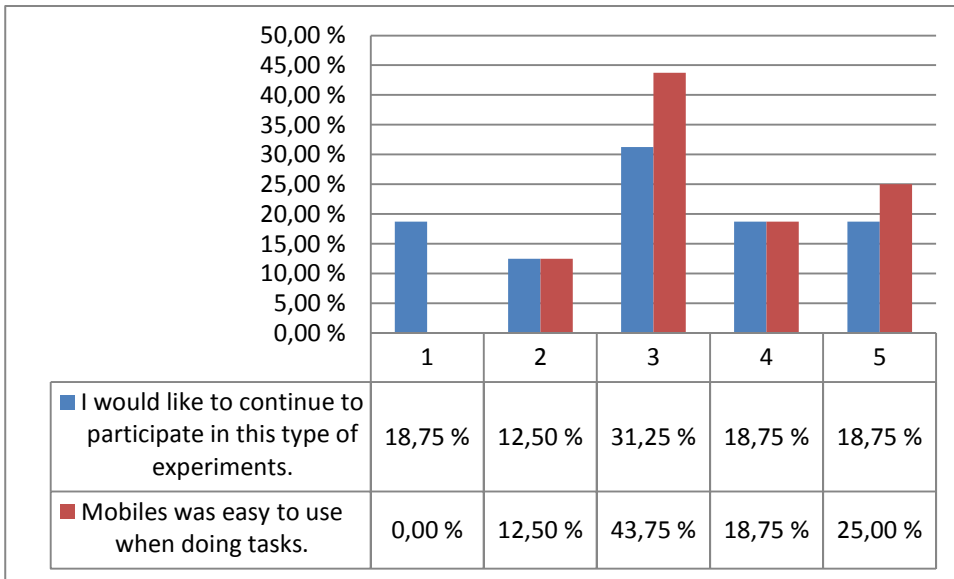
Over 40 % of pupils like to be on the museum and over 40 % of pupils found tasks nice.



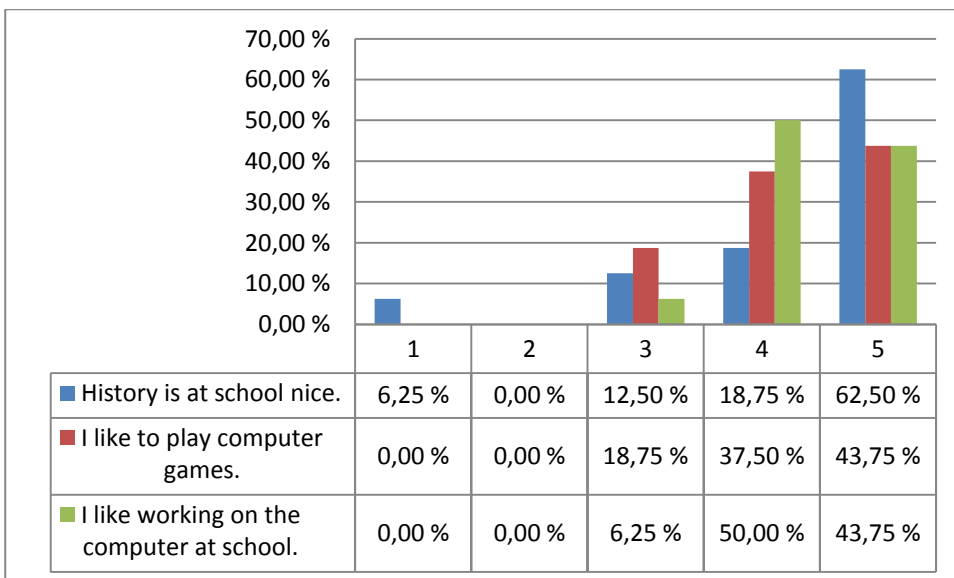
Pupils found some technical problems, but they liked to use mobile technology.



Pupils want to use mobile technology to studying also in the future. Pupils doesn't want to have tasks on paper.



Thirty percent of pupils don't want to take part this kind of experiments any more. Over forty percent of pupils found mobiles easy to use.



Pupils like history at the school and working on the computer at school.

Some open questions was put to pupils:

What on museum education course was the nicest?

- "using of mobile phones" (three answers)
- "When you got to be with friends and take pictures :)"
- "taking pictures " (six answers)

What was the most boring?

- “when phone doesn’t work” (two answers)
- “phones” (two answers)
- “(some of) the pictures were fuzzy” (two answers)

What was the hardest with cell phone?

- “taking photos”
- “taking accurate photos”

How you would do the system better?

- “by making camera better”
- “by making camera more accurate”
- “zoom”

With all pupils of this both cases I checked, was it really so that girls want tasks on the paper more than boys. Now result was statistically significant.

```
> AnovaModel.2 <- aov(paperiparempi ~ Sukupuoli, data=Moop)
```

```
> summary(AnovaModel.2)
```

```
      Df Sum Sq Mean Sq F value Pr(>F)
```

```
Sukupuoli  1  8.853   8.853  8.8037 0.005315 **
```

```
Residuals 36 36.200   1.006
```

```
---
```

```
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
> numSummary(Moop$paperiparempi, groups=Moop$Sukupuoli, statistics=c("mean", "sd"))
```

```
      mean      sd  n
```

```
Poika 1.333333 0.6859943 18
```

```
Tyttö 2.300000 1.2182818 20
```

9.4.2 Teacher's feedback

Teacher of class Juho Knuuti:

We discussed on school about the input of MEC, but we don't moved photos to the Opit system. The course was meaningful and with tasks, students had to explore the museum more accurate than normally and more rationally way. About the use of cell phones and Binder I would have liked a little more comprehensive guidance. Binder customer service I received good help. The pilot went well, we did not have bigger problems with cell phones, but the quality of the images is not fully been good. Was the reason in users or devices, but some of the pictures are very fuzzy. As a single experiment, the course is only a discrete thing, but combined with a larger whole it would be a very good package. Some students were sour, but I believe that most pupils felt that MEC was meaningful. I recommend the museum course with these tasks for 5-6 graders, as long as the students are familiar with the equipment and the course is a part of the larger whole of history lessons.

9.5. Lessons learned

1. Opit Binder was the first commercial mobile learning environment in Finland and has not yet any competitors. The price was too high especially in this economical situation in Finnish municipals, that's why it is not widely speared.
2. It is clever idea to connect mobile learning environment to traditional web learning environment, which are quite popular nowadays in Finnish schools. Maybe this integration should be more fixed so that for example Opit discussion forum can used from Binder application on the phone. Now Binder is only channel for collecting data in relation with Opit.
3. Ready to take use pedagogical models are needed inside this kind of commercial products. It is impossible to sell this kind of products to teachers if there is not easy ideas about it how to use observations from forests and museums in the school after field trips. Binder is in principle pedagogically well thought and planned learning environment, but it needs some teachers guide book included for us ordinary teachers.
4. Binder was not technologically ready when it was sold to the customers, but this is typical in many new fields of technology. Drummers sell products out before engineers get them ready.
5. Mobile devices used in commercial mobile environments should be quite new models with enough stability, processor power and big screen. Mobile terminal should not be the weakest link in the chain.
6. Mobile data connections are not so stable and all time available than fixed internet connections. With GPS there is also some delay some times.
7. Teachers that used Opit Binder do not have Opit learning environment in active use any more 2009 and 2010. Lempäälä Muncipal was cutting costs and Opit was one of the first savings target. If teachers would have been active user of web learning environment, maybe pedagogical use of observations would been easier in the classroom. We were jumping directly to mobile learning without e-learning and maybe that was the reason why pedagogical integration of course to ordinary class work was found problematic.

Sources

Mattila 2005

Mattila, P., Fordel, T.: MOOP – using m-learning environment in primary schools. In *MLEARN 2005*, Cape Town, South Africa, 2005

Laakso 2010

Laakso MAVI16 conference June 26-29, 2010, Tallinn University of Applied Sciences, Estonia

http://www.ttkk.ee/bw_client_files/ttkk_pealeht/public/img/File/yldine/2010/mavi/MAVI16_Laakso_etal.pdf

Ryymin 2008

Ryymin, Palonen, Hakkarainen: Networking relations of using ICT within a teacher community

Journal Computers & Education Volume 51 Issue 3, November, 2008

10 The fifth cycle: MLE-Moodle

MLE-Moodle is an open-source GPL-licensed ready to use mobile Learning system designed for mobile phones. It is a plug-in for the open-source learning management system Moodle (Modular Object-Oriented Dynamic Learning Environment), which is based on the social constructionist framework of learning.

With MLE-Moodle it is possible to enhance eLearning system to mobile Learning. Students can learn either with mobile phone (mLearning) or with PC /Notebook (eLearning). On the mobile phone student can either use phones own mobile browser to access MLE-Moodle or she/he can use a special **mobile phone application** which was designed for learning on mobile phones (called MLE phone client).(MLE-Moodle 2011)

Moodle can easily be taken to use with Apache, MySQL and PHP technologies. Moodle has lots of features like lessons, assignments, forums, quizzes, resources, Blog and Wiki. Now March 2011 there are more than 54000 Moodle sites in the World. It is very popular also in Finnish senior secondary school. In Lempäälä Senior Secondary School Moodle was taken to use 2004 and many teachers are using it now.

Philosophy of MLE-Moodle is described as follows:

“mLearning uses mobile phones as a medium for learning. With mLearning it is possible to use every kind of waiting-time for learning, no matter where you are. Examples would be:

Learning while you are waiting for the bus or the train.

Learning while you are travelling.

Learning while you are waiting at the dentist.

Learning, wherever you might want to learn.

The Mobile Learning Engine (MLE) enables you to learn **wherever** you want to learn, **whenever** you want to learn and **whatever** you want to learn. But if you are **at home or at school** in front of your PC / Notebook it would make no sense to use a mobile phone for learning. That's why the MLE is integrated with an **eLearning** system (in this case this eLearning system is Moodle). With your PC / Notebook you use the standard eLearning system, if you are away from your computer you can continue learning with your mobile phone.”).(MLE-Moodle 2011)

This means much deeper integration between mobile learning environment and traditional web learning environment than in case Binder Opit. MLE-Moodle is not only channel for collecting data to Moodle, but a way to use some of the Moodles core activities with mobile client.

MLE-Moodle supports these Moodle resources:

Quizzes:

A quiz tests, consists out of multiple choice, true-false, and short answer questions etc. Each attempt is automatically marked, and the teacher can choose whether to give feedback or to show correct answers.

Lessons:

A lesson consists out of multiple choices and each page ends with a question. The navigation through the lesson can be simple or complex and the Moodle Lessons work fully on the MLE. Same learning content can be used for eLearning and mLearning .

Assignments:

You can submit an assignment or view the correction via the mobile phone. The assignments can be uploaded files (audio/video/images) or plain text.

Surveys and Choices:

The Survey module provides a number of survey instruments.

Forums:

The Moodle forums are accessible through the mobile client. You can read and create / edit discussions and replies. You are able to attach self made pictures, videos or audio recordings to your discussions and forum posts which you can instantly record with your phone or you can choose from the file system.

Moodle Ressources:

You can access a variety of Moodle ressources on the mobile phone too, for example text, HTML Text, image, video, audio, links and directories.

A Mobile Learning Object:

A Mobile Learning Object is a learning object especially for the MLE. It can be stored on the mobile phone and afterwards used without any internet connection (offline learning). MLOs can be created with a built-in graphical editor.

Messaging:

MLE Moodle fully integrates into the Moodle messaging system. You are notified on the mobile phone, if a new message has been sent to you, no matter if the message has been created via a mobile phone or via the Web-Browser. That is why there is no need for SMS notifications. The Moodle block "Online Users (mobile)" shows the Web users, who is online and who is currently online with a mobile phone.

Mobile Tag:

With mobile tagging you can implement context based or location based learning scenarios. You can create tags which can be interpreted by the MLE (if your phone meets the requirements) or by any QR-Barcode Reader. Decoding a tag is as simple as taking a picture with your mobile phone. The Mobile Tagging module allows different types of tags to be created. You can either create a tag linking to an URL, or Moodle specific tags directly forwarding the mobile user to a given course or activity. It is even possible to assign geo-information (coordinates) to a tag. This can be used to emulate GPS capabilities when real positioning is not available.).(MLE-Moodle 2011)

The two ways of using MLE-Moodle are mobile phone client and mobile phone browser.

Mobile phone client is the special designed program for mobile phones to use such small devices for learning. It offers some advantages:

- Offline learning: download the learning content once and then learn without any network connection
- Easy to use: just click on a symbol in the menu of your phone and the learning application starts

- Better usability: the whole content and navigation is optimized for small devices
- All in one: with most modern phones you don't need any other third-party-application anymore.
- Compressed data-transmission through the use of a special gateway-server.

The download and installation of the mobile phone application for specific Moodle-server is integrated in MLE-Moodle.)(MLE-Moodle 2011)

Instead of an application that needs to be installed on the mobile phone, you can use the mobile phone browser which is already on your phone to access MLE-Moodle. This solution has its advantages too:

- No need to install an application on the phone - if you just want to go through a single quiz or a survey it is not necessary to install a full application.
 - Because everything is online, there is no need to synchronize or update your learning content, because nothing is stored on the mobile phone.
 - You can customize the look-and-feel, add your logo and slogan to the start-page.
- (MLE-Moodle 2011)

Origins of the MLE-Moodle are in the MOMO project, which stopped their development. MLE-Moodle took over their PHP code and fixed every bug found, enhanced the usability (especially the installation) and optimized the mobile client more. (MOMO 2011, MLE 2011)

MLE-Moodle is important step towards wide use of mobile learning. If a teacher is familiar with Moodle, it is not a huge leap to take MLE-Moodle to use. Installing MLE-Moodle to Moodle site is quite straightforward to Moodle administrator and for students familiar with Moodle MLE-Moodle is a natural way to use Moodle mobile way.

However, the future of MLE-Moodle is not clear. The newest version of Moodle 2.0 contains a huge number of core changes to the platform. The latest version of MLE-Moodle is from 13.5.2010. In the home page of MLE-Moodle there is text: “**Attention:** Do NOT use MLE-Moodle with Moodle 2.0!!!” We can only hope, that a new community of developers ports MLE-Moodle to Moodle 2.0.

10.1. Past projects with MLE-Moodle

In University of Rousse in Bulgaria it has been used MLE-Moodle in Physics education. They produced the lecture “**Superconductivity**” in Moodle and it can be used by means of MLE-Moodle. The text for lecture has been prepared in form as 58 Power Point slides. It presents one slide after another: what is superconductivity; discovery of the superconductivity; superconducting state; what causes superconductivity; history of superconductivity etc. A few video clips were added for visualization of the phenomenon. (Nancheva 2009)

In Indian Institute of Technology Bombay has been tested MLE-Moodle and they present a modification to its architecture for resource and network constrained environments. They installed and tested the MLE Moodle on some smart phones like N95, E60 and found it to be working satisfactorily. Also the J2ME client works on almost all Java enabled phones. (Sakharkar 2009)

There is not exactly reported experiments about MLE-Moodle available, so our reports are first ones.

10.2 Our Moodle server with MLE-support

Moodle server version used was 1.99 and MLE-Moodle was version 0.8.8.3.

Without the Gateway Server the mobile Client makes a direct HTTP-access to Moodle. The eBook-Mode with MLOs only works with the gateway-server and some older phones may have problems with large form-uploads without the use of the gateway-server. I installed own Gateway Server to same server where our Moodle is and it worked well.

A Message Server informs the user about new messages. The advantage of the Messaging-Server is that you are informed about new messages even if you do not make a request to Moodle. Otherwise the users are informed about new messages only if they access the Moodle server. To use a Message-Server is not necessary, but we used public server msm.mo2i.com.

MLE-Moodle link comes to Moodle's front page and also a link where MLE-Moodle Java-application can be loaded to the phone. When this software is loaded from that link, then automatically our Moodle-server's web address, Gateway Server's address and other settings are coming to Java-application's settings. So students can start use of MLE-Moodle by only writing their username and password.

Start | Login

MLE-Moodle

Please log-in!
 Login

[MLE install \(phone software\)](#)

Powered by [MLE-Moodle](#)

Start | Inbox(0) |

MLE-Moodle

Welcome **sivari!**
 [My Courses](#)
 [Messages](#)
 [Community](#)

Extras:
 [Mobile Tags](#)
 [MLE install \(phone software\)](#)

Powered by [MLE-Moodle](#)

10.3. Case 1 - museum education

First test of MLE-Moodle was at Kuokkala museum road with same tasks than with Binder Opit. The pupils were from 2th - 5th grade from Nurmi village school.

We used phones own mobile browser to access MLE-Moodle (figure 1). This was first test of MLE-Moodle in Finland. The phone model used was Nokia 6220 Classics.

We used Moodles discussion forum to implement museum education course (figure 2). Every question was one forum and every team posts there one post with photo and text. We added also to questions some intro text that tells about generic information of museum targets and was a like virtual museum guide (figure 3).

We doesn't used tags, because we doesn't get it to work even that MLE-Moodle community friendly fixed some bugs we found inside tag-system. We simply numbered the tasks and give same numbers to the discussion forums. Tags added value is not significant for mobile learning; it is more like technological toy.

Phone camera pictures can be sent to Moodle discussion forum with MLE-Moodle. Image must first, however, temporarily to save to camera's memory card, from which it transferred with the phones operating system and browser to Moodle discussion forum with "add attachment" - function. Our young pupils survived this well, although the feature is not particularly convenient because many clicks needed.



Figure 2

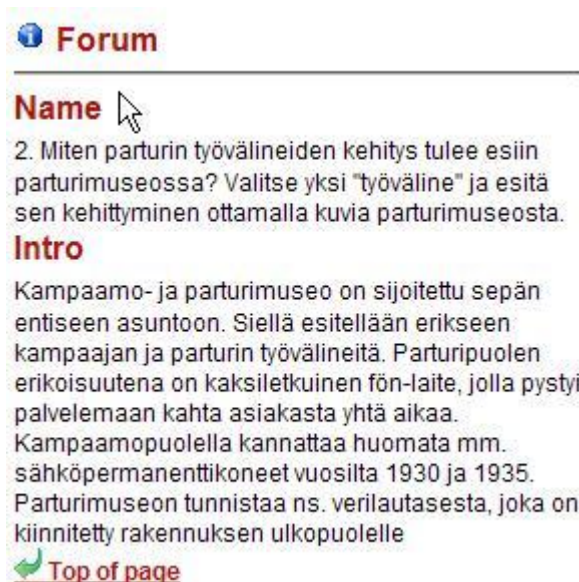


Figure 3



FIGURE 4

“Shoot one strange object, and invented a name for it and tell what the purpose of the object is.” Team Hippos answer is this photo (Figure 4) and text “machine to make grated cheese, from top put the cheese inside and then turn the lever, and grated cheese comes out”



FIGURE 5

“Smithy of K. A. Koskinen was completed in this place in 1910. What may have been manufactured in this smithy?” In figure 5 is answer of the team soft ice cream.

All five teams get MLE-Moodle to working. So as you can see, quality of photos was good.

10.4. Case 2 – biology exam in the woods

In this second experiment we want to use MLE-Moodle Java-application.

10.4.1 The tasks

Pupils in the experiment were 8th grade biology class group, which had about 18 students. In the design of teaching experiment was special attention paid to the fact that the activity is closely tied to the curriculum. This was achieved clearly, because these tasks were part of the student evaluation.

Tasks were

1. Tree height: Measure the height of the tree, identify it and take a photo about it.
2. Tree species: Identify from the close range 6 different species of trees, photo them and send pictures and types to Moodle. You can find help in your phone's browser bookmarks with name tree species or directly at <http://www.puuproffa.fi/arkisto/puulajit.php>
3. Mosses: Identify at least three different moss species and photo them. Take a small wad moss in your hand and photo it in hand. Send your images and the names of species to Moodle.
4. Forest Type: Identify the forest type and send the answer to Moodle. Justify your answer.
5. Mushroom species: Locate and photo at least 6 different mushrooms. Remember all the mushrooms groups. The identification gives additional points. Send pictures to Moodle. How polypores gain their energy from? Post a reply to Moodle.
6. Pioneer species: What pioneer species can be found in this open area. Send species names and images to Moodle.
7. Field layer plants: Photo and identify six field layer plants. Send your images and type the names to Moodle. You can continue your journey back to class. If you get lost call your friends / school to get help.

10.4.2 Technology

Deployment of the MLE-Moodle Java application was not a straightforward process.

1. We had trouble to finding a phone where a Java application can be installed and where the application would support a camera phone and the GPS system.
2. Problems at installing at least partly due to the security certificate. When the date of the phone calendar changed the year before the date today, the application can be successfully installed.
3. Once the appropriate phone was found and the application was installed, there was an embarrassing problem. When the camera view of the application was used to taking photo, the picture came from a different point where you have targeted! When to the phone installed the latest version of its operating system, the error is resolved.

Time needed to this technical problem solving was an estimated two men working week. It is clear, that ordinary teacher is not ready to do this kind of beta- testing when a lot of trial and error work is needed.

In this experiment we used Nokia 6700 slide phones. Nokia describes phones this way:



“Pictures get us talking

The colourful and compact Nokia 6700 slide is designed for you to capture and share life's special moments, and to enjoy your choice of messaging and social networking services.

Photos and video

Take great pictures with the high quality 5 megapixel camera with Carl Zeiss lens.

You are always ready for those special moments with the dedicated capture key, autofocus and dual LED flash.

View your photos on the bright 2.2" screen, edit on your phone, and instantly share your pictures to Share on Ovi, Flickr, Picasa or other sharing sites.

Shoot video, stream video from the mobile web, and make video calls by taking advantage of the secondary camera on the front of the phone.”

The resolution is 320 x 240 pixels and the software platform is S60 3rd Edition.

The phone has the characteristics (inside price range), suitable for use with mobile learning. The phone is small in size, so it is easy to take with. The screen size is sufficient to searching for information online from Internet and looking preview of images. Phone price is about 170 Euros and they were purchased 6 pieces. Students were divided into groups of three and the group gained access to one phone.

When the phones were distributed for students to try, the first question raised by them was how much the phone costs. In the woods, a student wondering of poor image quality said that his own phone has the 8-megapixel camera.

We used Elisa's 3G access with unlimited data transfer (384 kbit / s). Phones were installed to blocking calls and text messages to prevent abuse.

We organized for students a chance to try the application on the phone before the forest track. While the students are "digital age natives", there was a clear need for separate user training. When doing the assignments, there were many steps and it requires many keystrokes. Camera phone use, such as a picture taken with the preview, was also important to practice. The transition from MLE-phone application to the web browser and back again trained also, because in the one task there was a hint for pupils to use public web page.

Some students were worried and unsure when they tried for the first time application. Some pupils grieve if they will remember in the woods in a real situation, what all the buttons to press. In the test day pupils coped well, especially when in the first tasks we give if necessary support to use of the

phone. One group of the six groups has serious problems with technology. Their findings in three first tasks did not make their way to Moodle. Fourth task forward they also knew how to act correctly.

Uploading pictures from phone to the server went mainly fast. Although, at times the students asked why the download bar does not move. Students are accustomed to fixed high speed computer network connections and they expected that the phone's data transfer is at the same level.

Only one cell phone once demanded a restart. Application functionality is in beta testing before task course found certain. The need for restart is very rare, and pictures are transferred to the server 100% certainty.



FIGURE 6



FIGURE 7

The weather was rainy and gray, so the lighting for taking pictures was poor. Some of the images became blurred and stripey (figure 6), but there were several successful pictures (figure 7). Within the application using the camera flash and camera focus feature was not available. If you need to take accurate and high-quality images, especially if the lighting conditions are poor, it is therefore appropriate to use MLE-Moodle with phone browser. In this case, you have all the features of the camera.

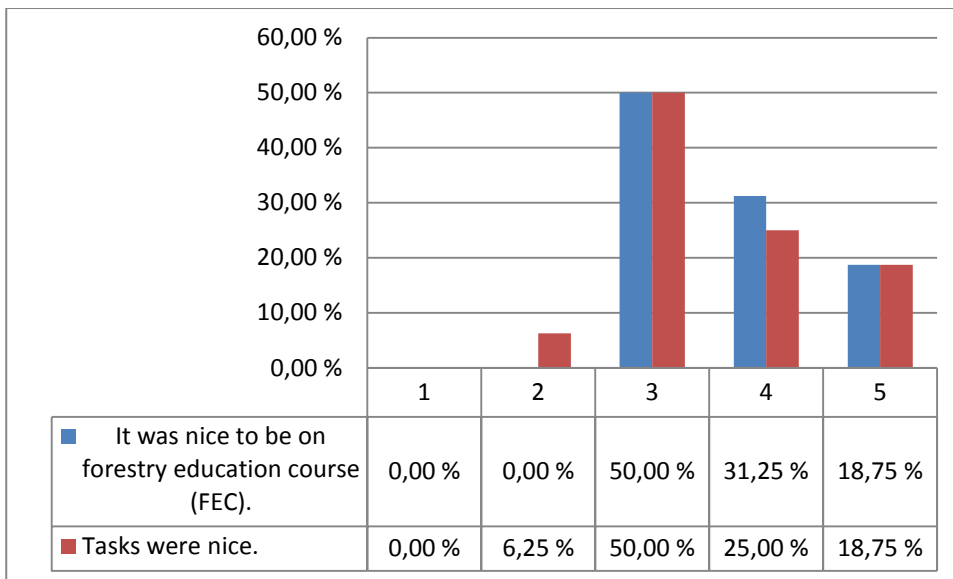
We made a number of assurances

- we tested the application in all the phones in the previous week
- batteries were loaded over the weekend (this is not obvious that batteries are loaded when starting mobile learning experiment)
- in the morning before going to the track we ensured with one phone that the system works
- the technical assistant was on the track with a mini laptop and he examined if students' answers arrive to Moodle and the students were asking whether their responses came in to Moodle and that the quality of the images was sufficient

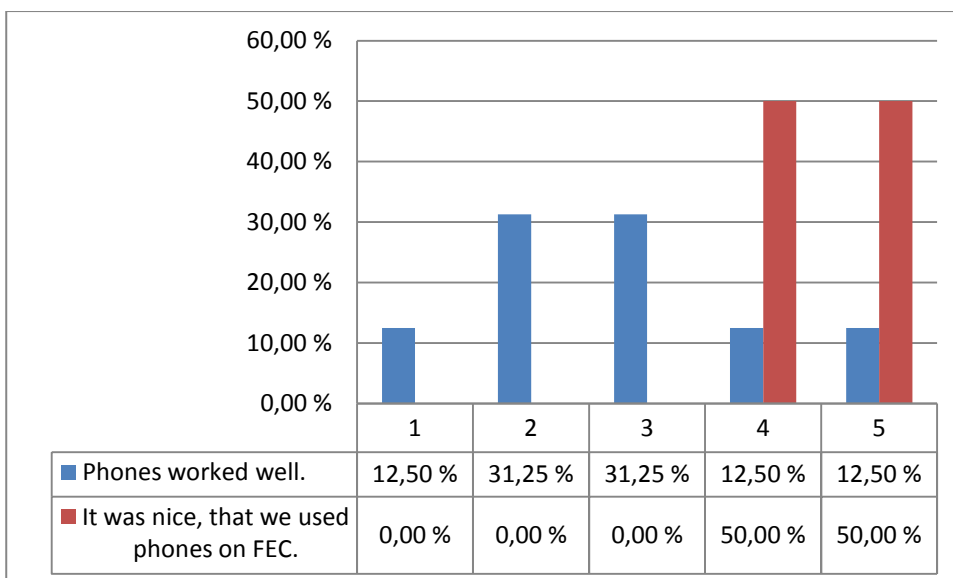
10.4.3. Survey for pupils

On the class there were 6 girls and 10 boys. They have all own mobile phone and all can use computer at home. They have all own Facebook or IRCGallery profile and 11 of them has updated it with mobile phone. Seven of them take photos with mobile phone weekly. Only two of them use mobile Internet weekly.

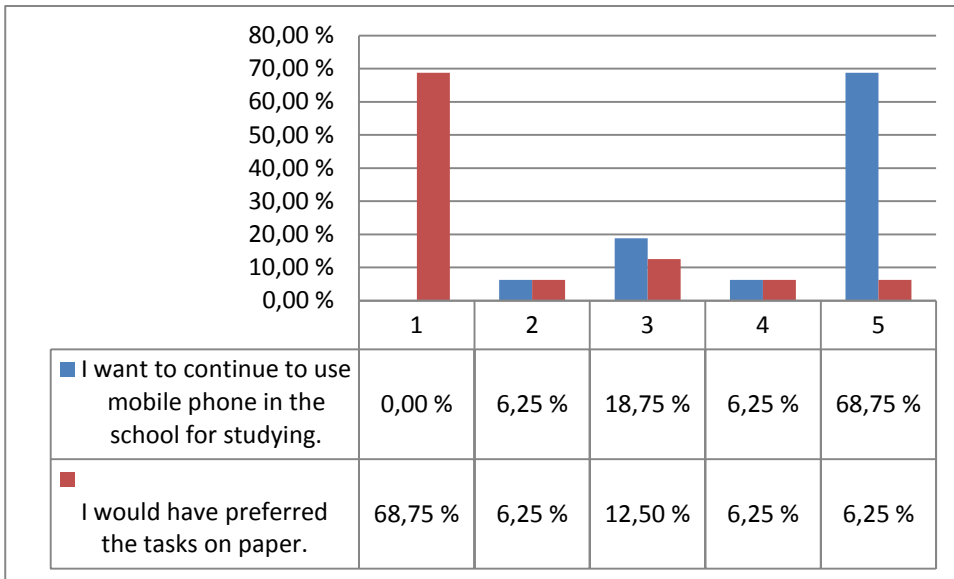
We have only six mobile phones with application on the task course, so pupils made tasks in the groups. Eleven of 16 pupils used MLE-Moodle on the pathway.



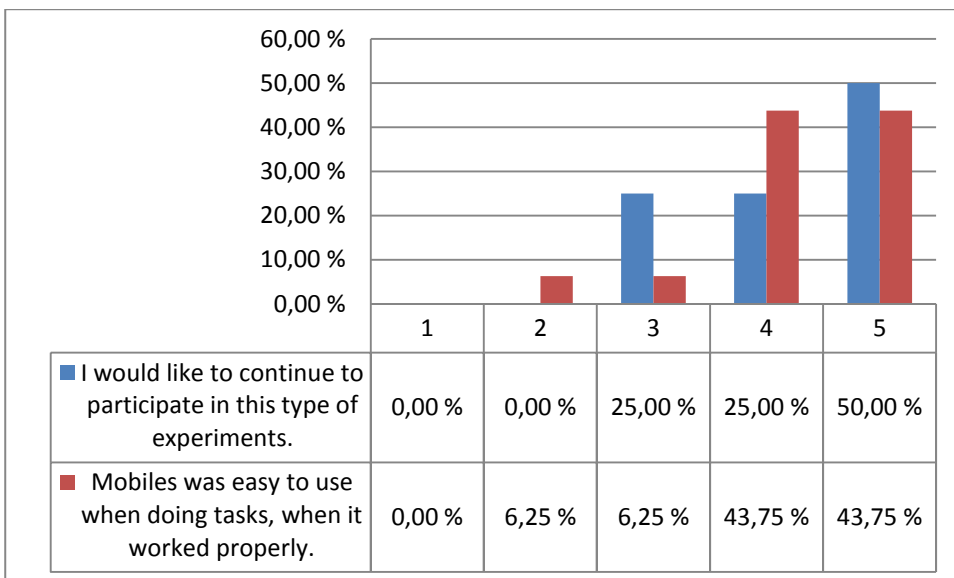
There was not pupils that doesn't like to be on the forest.



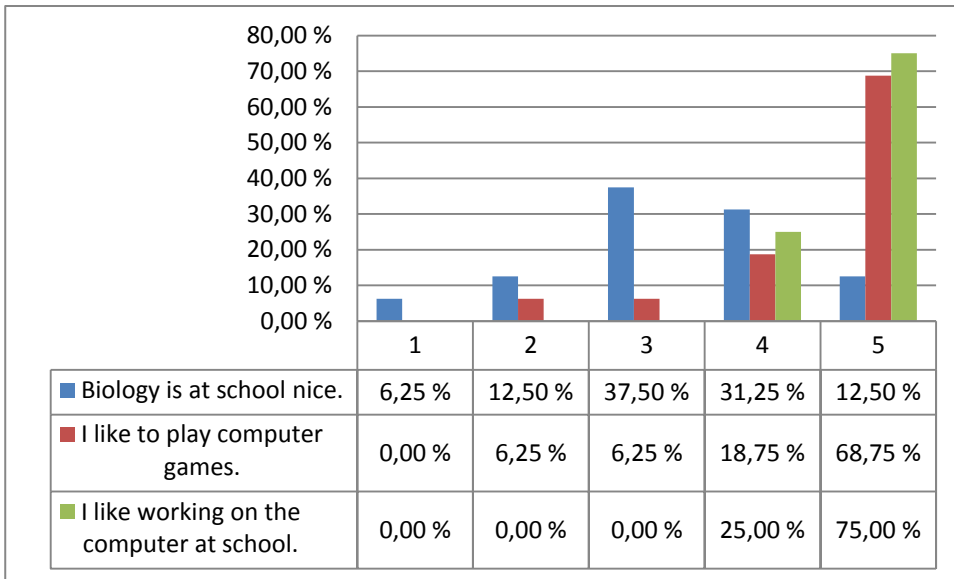
Only 25 % of pupils was satisfied to how phones were working, but all felt it nice to use them.



Pupils want to use mobile technology to studying also in the future. Only few pupils wanted to have tasks on paper.



There were not pupils that don't want to take part this kind of experiments any more. Pupils found mobiles easy to use.



Some open questions were put to pupils:

What on museum education course was the nicest?

“To get out from classroom.”

“Walking in the forest.”

“Groupwork”

What was the most boring?

“Rain”

“Internet was not working one time.”

“Waiting when phone was loading pages”

“Mushrooms”

What was the hardest with cell phone?

“Get a good photo”

“Photographing”

“using Moodle”

How you would do the system better?

“Better Internet connection”

So pupils welcome mobile learning in the forest and MLE-Moodle quite well.

10.5. Lessons learned

8. MLE-Moodle is a new approach to mobile learning. It connects mobile learning environment directly and bidirectionally to traditional web based learning environment. Like Moodle it is free to use, so there is a lot of potentiality within it. Why it is not widely speared?
 - Peoples involved in mobile learning projects want to use MLE-Moodle Java-application (merely than MLE-Moodle with phones own browser) and it is not always easy to take use as in our case can be seen
 - MLE-Moodle is a quite new product.
 - If Moodle environment is from external service provider, they are not always ready to install Moodle extensions like MLE-Moodle; there can be some risks (security, database integrity) with them.
9. In open source products there are also bugs of course. MLE-Moodle community fixed found mobile tag decoding bug for us rapidly. But if community of open source product is not very active, you are in our own. With commercial products you can always complain to sellers.
10. We used brand new phones and there were not a lot of hiccups. Biggest problem was quality of photos when MLE-Moodle Java-application was used. There was not possibility to use zoom or flash inside it. But if you use MLE-Moodle with phones own browser you can use directly phones camera with all features.
11. With MLE-Moodle many features of Moodle comes available with ordinary mobile phone. An interesting scenario would be mobile learning inside class room in ordinary lesson. Every pupil would have access to Moodle with her or his own phone (one device – one pupil). This is the place for further research. Scenario is realistic only if fixed price mobile data connections come popular or phones with WLAN support come more frequent.
12. Android Tablet-PC:s are now making breakthrough. With 7 or 10 inch screen and WLAN/3G it is possible to use Moodle directly without MLE-Moodle. Price of cheap WLAN-models without 3G is 100 Euros so it is possible to equip with 2000-3000 (+ price of WLAN access point) Euros a movable mobile learning classroom. Even poorest Finnish municipals have able to afford this.
13. The future of MLE-Moodle is unclear. Would there never been support for Moodle 2.0? Hopefully some new community of developers takes source code and starts to develop it, like in case of MOMO. Another “threat”: Is it any more need for light user interfaces or is power and screen size of new mobile devices making them useless. In developing countries need of light user interface is clear also in the future and also in Finland if we use pupils own mobile devices.

Sources

MLE-Moodle 2011

<http://mle.sourceforge.net/mlemoodle/index.php?lang=en>

MOMO 2011

<http://www.mobileclassroom.at/momo18/>

Nancheva 2009

M-learning of the superconductivity; Multimedia in Physics Teaching and Learning MPTL 14

http://www.fisica.uniud.it/URDF/mptl14/ftp/full_text/T1_14%20Full%20Paper.pdf

Sakharkar 2009

MOLE: An Extension to MLE Moodle, Hemant Sakharkar, Sridhar Iyer and Malathy Baru *Department of Computer Science and Engineering Indian Institute of Technology Bombay* National Conference on Open Source Software, Mumbai, India, May 2009.

<http://www.it.iitb.ac.in/~sri/papers/mle-ncoss09.pdf>

11. Similar projects

11.1. MobilED Platform

The focus of MobilED project was on how to use low-cost mobile phones, which are commonly available even in the developing world, while ensuring that participants not only access information, but also contribute it. Based on these prerequisites, project developed the concept of a mobile audio wikipedia. (Ally)

The goal of MobilED platform is to enable the usage of a public information source (Wikipedia etc.), via a mobile device (a cellular telephone etc.). This is achieved by making use of real-time communications technologies(e.g. speech-based technologies such as text-to-speech engines and interactive voice response) and messaging technologies (e.g. SMS). Users of the system are also able to contribute data to the information source, by recording and uploading audio clips via their telephones.

The MobilEd platform uses three main technology platforms to achieve its goal:

- SMS communication interface/gateway (such as Kannel/Alamin) to send and receive SMS's,
- the Asterisk Open Source PBX for audio telephony communications, and
- a MediaWiki server with suitable content, such as en.wikipedia.org.

The user of the system uses SMS-capability of his/her cellphone to request an article from the MobilEd platform, by entering the title of the article, and sending the message to the phone number assigned to the the MobilEd. The MobilEd platform responds by calling the user and delivering the requested article via an audio telephone call. The user is also allowed to contribute to the local MediaWiki server by recording his/her voice over the telephone.

The first pilot of MobilEd was conducted in South Africa with the learners ranged from age fifteen to sixteen. The theme was HIV/AIDS. The learners from Cornwall Hill College were all from affluent homes and most already owned a mobile phone. During the pilot there were a few technology hiccups. There was overwhelming official support and student enthusiasm for using mobile phones in the classroom.

The second pilot was run at a local government school, Irene Middle School. The learners were from very poor backgrounds. Most learners did not own their own mobile phones, and many had never used a mobile phone. The MobilED platform was significantly enhanced and upgraded to version 2. The Irene Middle School learners had a lesson on HIV/AIDS based on the same lesson plan developed for the first pilot. The learners were given a longer period of time to get familiar with the mobile phones. This MobilED pilot was once again a success, with support from both learners and teachers. Learners were motivated and clearly enjoyed the learning process. The server logs showed that many of the learners spontaneously used the service to get information about many other topics. Although the learners were not ICT-literate and very few had mobile phones, they took only a very short time to familiarize themselves with the technology. During this pilot there were very few technology problems and this contributed to a much better experience for these learners.

In pilot 3 observed the collaborative behaviour of groups of children from different cultural and socio-economic backgrounds. There was also introduced and test the use of MMS/SMS technology as part of the MobilED platform. Another aim was to test the platform with younger children. The first part of the pilot consisted of ten learners (aged thirteen to fourteen) from Irene Middle School and from Cornwall Hill College who were invited to the Meraka Institute as part of a learning activity to create a reusable multimedia slide show about three technology projects developed by the institute.

Their task was to use the mobile phone for capturing information, taking photos, recording and storing, compiling a slide presentation with all these and MMSing to the server. The learners seemed to enjoy the activities and were extremely creative with their photographs.

The results of the pilots show that the use of a mobile phone as technology tool to aid the learning process can work extremely well. The learners were very open to using the technology and the teachers could focus on facilitating the learning process, rather than having to grapple with new, unfamiliar technologies as traditional computers.

11.2 A Platform for Server-Side Support of Mobile Game-Based Learning – mGBL

mGBL was an EU-funded three-year research project into mobile game based learning. The mGBL platform has been developed to meet following requirements:

- There had to be a way to deliver different learning content to the mobile devices.
- Teachers have to be able to control the learning progress and react to the results of pupils playing mobile games.
- Devices have to be coordinated for collaborative games.

The platform supports the full cycle of mobile game-based learning, from the selection of games and game styles, to game authoring with definition of learning content, to the practical administration of game play and its results.

The main technological design decisions for the mGBL platform were made in the first half of 2006. The market for mobile devices was split into devices with very different operating systems and hardware resources. The only common denominator of a wide range of mobile devices was the Java 2 Micro Edition runtime environment (J2ME). mGBL project decided, that also server platform should be based on Java technology, server-side Java. Project also found, that games which are based on messaging like SMS and MMS instead of deployable mobile (Java) applications can easily be used on a large spectrum of mobile devices and do not have to be updated for new devices and operating systems. This is same kind of decision that I made with my MLE, but my MLS was PHP&MySQL based construction instead of Java.

Server solution of mGBL based on Apache Tomcat web server, Apache Struts web application framework, JBoss application server, MySQL database and Hibernate Object-Relational Mapping (ORM) tool.

All administrative features can be done via a web browser. Access rights are handled according to a role-based security concept. Administrative users can send SMS and email messages to single users or users grouped in user sets for example to inform game participants about tasks to be performed or the current status of the game. It is also possible to automate game management by scheduling the sending of messages at specific points in time.

The mGBL gives support the complete cycle of mobile game based learning including finding of appropriate mobile game types for a range of learning purposes and for different learning modes. A game style selection tool was included in the platform, which allows specifying desired properties according to categories learning content, learning activities, cognitive processes, intelligences and number of players. After a game type has been selected, information about appropriate games can be displayed, including descriptions, screen shots and user comments.

Games and game templates available are managed in game management pages, which are accessible via the administrative web interface. The game authoring area is the place where teachers can enter learning content based on game templates. In a quiz game, for example, this could be questions and proposed answers combined with the scores assigned for correct answers.

The platform receives incoming SMS and MMS messages via commercial gateway providers, who translate messages to HTTP requests and e-mail messages. Depending on incoming SMS and MMS information, different tasks, such as sending SMS messages and player score changes, are initiated. Similar actions can be performed independently of incoming messages at configurable points in time.

In order to allow non-technical users to configure these tasks, the platform supports creating lists of prepared interactions to be performed based on incoming messages, the mobile phone numbers used therein, and their text or graphic content.

The biggest trial of mGBL took place in Vienna at the beginning of 2008 with more than 100 students with an average age of 24 years. In a pervasive game application they were given tasks by SMS which they had to answer by SMS and MMS.

Feedback was gathered from students. Many students had technical problems sending MMS. The high costs of having to send MMS messages were criticized by students (use of Mbuni in my MLS is one solution to costs) and most students generally preferred SMS to MMS messages and also specifically preferred blogging via a web interface to blogging via MMS. No such technical problems were reported with SMS messaging and students eagerly performed the tasks based on this simple text-oriented communication. The game contents and the learning progress achieved received quite diverse reviews, showing that questions and tasks have to be carefully chosen to satisfy the needs and interests of the target audience. This found is parallel to my findings.

12. Discussion

12.1. Summary of main results

12.2. Implications of the results: Guidelines for ordinary Finnish schools starting mobile learning

12.3. Future research