Int. J. Engng Ed. Vol. 24, No. 1, pp. 84–91, 2008
Printed in Great Britain.

0949-149X/91 $3.00+0.00
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Designing and Implementing Educational Mobile Services in University Classrooms Using Smart Phones and Cellular Networks*

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In this paper we report the results of our ongoing activities regarding the use of smart phones and mobile services in university classrooms at Växjö University. The purpose of these trials was to explore and identify which content and services could be delivered to the smart phones in order to support learning and communication in the context of university studies. The activities were conducted within the MUSIS (MUlticasting Services and Information in Sweden) project where 41 students from two different courses at Växjö University participated during a period of three months. Generally, the services integrated transparently into students' previous experience with mobile phones. Students generally perceived the services as useful to learning; interestingly, attitudes were more positive if the instructor adapted pedagogical style and instructional material to take advantage of the distinctive capabilities of multicasting. To illustrate, we describe a number of educational mobile services we have designed and implemented at Växjö University. We conclude with recommendations for increasing the potential for successful implementation of multicasting mobile services in higher education, including the importance of usability, institutional support and tailored educational content.

Keywords: mobile learning; educational mobile services; smart phones

INTRODUCTION

IN THE PAST DECADE, the Internet has spawned many innovations and services that stem from its interactive character. The emergence of ubiquitous and inexpensive microprocessors and wireless networks has led to the wide deployment of mobile devices that allow us to access and to handle information almost anytime and anywhere [1, 2]. Diverse multimedia applications have flourished with recent advances in hardware and network technology, the proliferation of inexpensive video-capture devices and widespread adoption of the worldwide web. All these forms of interactive multimedia and communication offer new possibilities for supporting innovative ways of learning, collaborating and communicating [3, 4].

While the mobile/wireless computing revolution is having a major impact on the ways people communicate and interact, this transformation does not live up to the promises and expectations when it comes to schools and universities [5, 6]. Thus, there are a number of questions that deserve further exploration. What are the implications of using mobile computing and wireless communication for supporting learning and teaching? What new scenarios and applications will emerge?

* Accepted 6 November 2007.

THE MUSIS PROJECT

The main objectives of the MUSIS project are to explore, identify and develop a number of innovative multicast mobile services with multimedia information to be distributed over wireless networks using multicasting solutions at university campuses. MUSIS (http://www.musis.se) brings together TeliaSonera (TS), Sweden's largest telecom operator, the City of Stockholm, Växjö University (VXU), and Bamboo MediaCasting, a company pioneering in the field of cellular multicasting. Also, the Royal Institute of Technology (KTH) in Stockholm and Smålandsposten, a local Swedish newspaper, are strongly involved in this project.

Multicasting mobile services developed in MUSIS are organized as a range of content channels to which users can subscribe. Each user can build a personal portfolio of channels that interest them. Multimedia content is sent, according to a predefined time schedule, to subscribers over the GPRS (General Packet Radio Service)

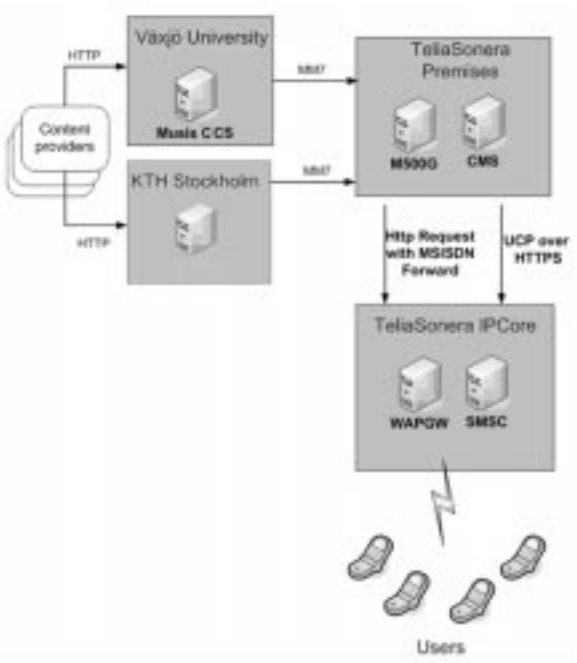

Fig. 1. MUSIS generic architecture.

network using wireless multicast technology [7]. It is also possible to program the system in order to send content to the phones based on discrete events. The content sent to the phone is downloaded in the background and is stored in the phone's memory card. Once the content has arrived, the phone beeps. To see the message, users can then interact with the MUSIS client installed in the smart phone as often as required.

This approach differs radically from the latest type mobile services offered by the telecom industries which are using streaming technology. The digital content used in our trials included TV news, music, entertainment videos, general information related to student's activities to lecture notes (including video and audio), and specific information related to the different courses. The size of each MUSIS message sent to the phones can be up to 1 MB (several times larger than the actual size of a single MMS). Thus, we are able to send up to 2 m 20 s of high quality video in 3GP format (a proprietary video format for cellular phones) or 10 m of good quality audio. Students were also able to send and receive MMS (Multimedia Messaging Service) messages. These two latest facts allow all phones to both receive and send audio and video content.

Technical aspects

A complex technical infrastructure has been developed in order to deliver the different mobile services to the students. This task requires complex software solutions that connect and combine the content coming from the different actors. Figure 1 illustrates the generic technical architecture and the different hardware and software components used in the project.

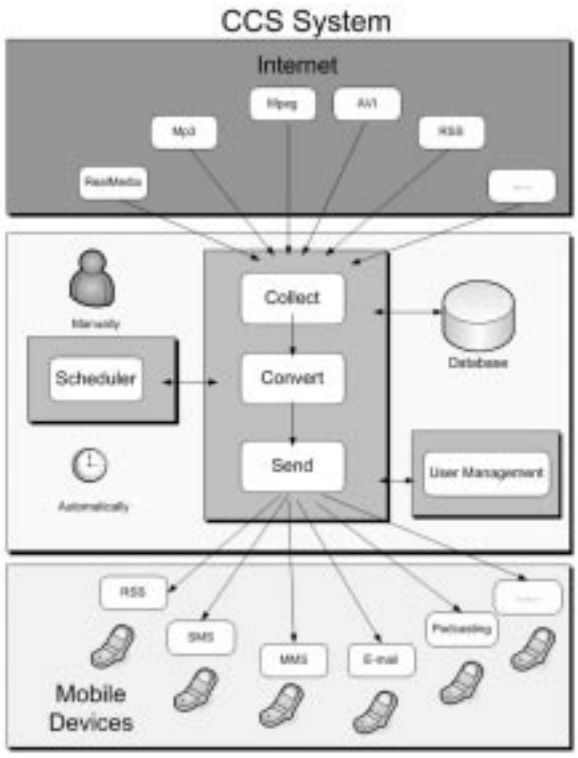

Fig. 2. Generic illustration of the CCS system (Collect, Convert and Send)

Bamboo's equipment provides the multicasting feature in the GPRS network. The content management system (CMS) located at TS is responsible for scheduling the content transmissions. The MUSIS CCS (Collect, Convert and Send) developed and implemented at VXU is responsible for collecting, organizing and converting the different digital material coming from all content providers (including educational material produced by the teachers) as described above. The MUSIS CCS system provides tools to manipulate content automatically and transmit it to Bamboo's router for distribution to users. The CCS can source content based on predefined rules, convert it to formats that are supported by the mobile handset and transmit it to Bamboo's server. These activities can be automatic without human intervention.

Figure 2 below describes the generic architecture of the MUSIS CCS system. The system is based on several different inputs and outputs. It is scaleable and consists of modular, reusable and easily expandable components to be able to deal with new types of content. This includes all features, i.e. the collecting, converting and the sending mechanisms.

The CCS system has been designed and implemented in order be able to collect and convert the following content types:

- Real Media format → AMR (audio). *AMR is The audio codec used in the 3GP format*
- MP3 → AMR (audio)
- RSS → AMR (text-to-speech)

- RSS → HTML (text)
- iCalender → HTML (text)
- iCalender → VCS (text) *VCS—vCalendar file, a calendar format used in many mobile devices*
- Real Media/Windows video → 3GP (video)

One study at Växjö University, part of the MUSIS project, focused specifically on the question of whether students would find a mobile phone useful for supporting their learning, particularly whether multicasting mobile services would be suitable for supporting learning and other activities related to their academic life. The study aimed to look at the patterns of use of various mobile services and the impact on students' learning habits. We were also interested in determining what type of functionality is required for educational mobile services to be considered useful. Our results lead us to advocate a comprehensive approach regarding the introduction of smart phones and mobile services in university classes, taking into account not only technical features but also individual, social and organizational aspects of technology adoption.

METHOD

Participants

Participants in this study were gathered by recruiting volunteers from students enrolled in two courses offered at VXU during the spring term of 2005: one course in the School of Humanities and the other in the School of Mathematics and Systems Engineering. After a short presentation delivered by members of the research team at the beginning of the term, students volunteered for the study, 22 from the School of Humanities and 19 from the School of Mathematics and Systems Engineering. Each volunteer was given a smart phone for the duration of the school term (three months).

Each student signed a contract of use which specified an obligation to participate in the project in return for free use of the phone and a little money for phone calls. The project also provided continuously available online and face-to-face support. The project began with a workshop session to familiarize the students with the smart phone and the software.

Participants ranged from 19 to 40 years of age, with a mean age of 26. Nineteen were female and twenty-two male. All 41 students already owned at least one mobile phone at the start of the project. Before joining the project, students in this group averaged 28 USD a month on their own phone service. Twenty per cent of the 41 students participating in this study spent more than 45 USD a month.

Equipment and mobile educational services

The smart phone provided was a NOKIA 6600/6630 running on a Symbian operative system, with 128 MB memory. The phone has an Internet browser, a bright 65,536-colour TFT display, a camera equipped with digital zoom, a video recorder with audio and a RealOne player for playback and streaming of 3GPP-compatible and Real Media video clips. Additional applications include a personal information management (PIM), a calendar and a contacts database. Users may synchronize contacts and calendar stored on the phone with data stored on a personal computer. Figure 3 illustrates the NOKIA 6630 with MUSIS client interface to access our different mobile services.

Fig. 3. MUSIS client interface.

Technical development of MUSIS services took place concurrently with this study, which meant that the services and capabilities of MUSIS changed over the course of the project. During the period March 1st–April 30th, all participants accessed the same set of channels, receiving approximately 5–7 MUSIS messages (push technology) daily. One of these channels carried educational content related to their VXU course. Subscription to the educational channel was compulsory throughout the project.

Beginning May 1st, users were able to subscribe to up to 30 channels of their choice using a Web interface (both available via a PC or a mobile phone) specially developed for this project. Results relating to these other channels are under preparation and they will be presented separately. Approximately 10 per cent of the total MUSIS messages sent to the phones were on the educational channel. In this paper, we focus specifically on our experience and results with the educational channel.

During the first month of the project, we experienced some technical problems in that students were billed for the use of the phone and services (the researchers pledged there would be no cost to the student). Although this problem was solved through open discussion in focus groups and by

individualized support to each participant, it did contribute to negative attitudes towards the different services.

Educational material delivered for this project include small 'micro lectures' in video format, voice-based course information and assignments and specific information related to the logistics (calendar information, cancellation of lectures and so on) of the different courses. In these lectures, the audio-based and text information were developed for (and sometimes tailored to) the phone. This material was produced by the course instructor, for which purpose we designed a special web interface for the teacher to use. We also developed a number of solutions that allow internet-based educational resources used in the course to be sent automatically to the phones. Instructors were given a smart phone of the same type given to the students.

An example of an application we developed for educational content uses java and XML to convert the instructor's contributions on the FirstClass (FC) forum to an RSS (Rich Site Summary, an XML format for syndicating Web content) feed that it is then multicast to the phones. FirstClass is a communication platform used at Växjö University mainly for distance education but also for campus-based courses. There are two ways of accessing the FirstClass application. Either the students use the FC client software or they use a web-based client directly from any browser. In the current version at VXU, there is no way to deliver FC content to mobile phones. Our application has been designed to overcome this problem. Figure 4 below describes the architecture of this application.

Our java application runs in the background of the FC forum, so the instructor's contributions to the forum are automatically transformed into a format appropriate for the phone. The content from the FC forum arrives to the phones as a file in HTML format that can be viewed with the phone's internet browser. A database call is made to check if there are any new items in the RSS-feed. If so, the XmlTransformBean parses the RSS-feed and transforms every new item it into an HTML file, using an XSL-file. Then the VaspBean can send the file to the phones via the M500G server connected to TeliaSonera's mobile network.

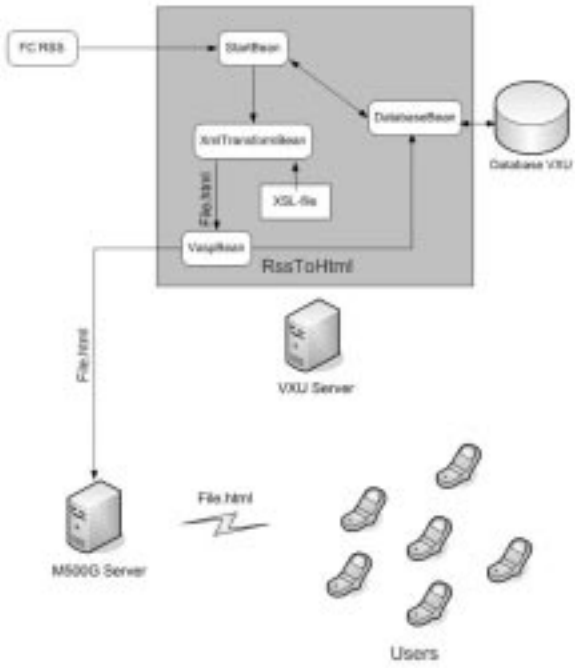

Fig. 4. Transformation from the FC RSS flow to HTML.

Data collection

Given the exploratory nature of this study, we used multiple methods to collect data. This allowed us to surface patterns of uses and attitudes that could be investigated more specifically in future studies. All data were collected in Swedish.

First, in weeks 1, 5 and 10 of the project, participants completed web-based questionnaires. The first survey included items that measured personal attitudes toward mobility, attitudes toward media formats and how much different media formats were used. The second and third surveys included items regarding perceived effect of the phones on learning, preference for different media formats, preference for channels and perceptions of telephone functionality and usability.

Second, members of the research team facilitated four focus group interviews with 15 participants; these were videotaped and transcribed. The focus group ranged in size from 3–6 participants. The interview covered issues regarding the participants' perception of the project in connection to the services, their functionality and their usefulness. Additionally, the participants were asked to suggest and discuss other educational mobile services that could be developed.

Third, electronic copies of communication between students and members of the technical support team were archived. These messages were generated through a FirstClass discussion forum, or through an e-mail listserv. On average, two or three students on a weekly basis contacted the technical support team to report incidents at the beginning of the project. This was mainly concerning technical problems.

Finally, a 90 minutes workshop with the students was held at the end of the term, which was videotaped. Its purpose was to carry out an open discussion with most of the students to get an overall view of how they experienced the project. The main objectives of this activity were to assess the usefulness and quality of the services, to identify problems experienced by the students and to explore what future MUSIS services could look like.

RESULTS AND DISCUSSION

General use and attitudes

Most students participating in the MUSIS project had mobile phones of their own before

they volunteered. Therefore, delivering content directly to the phone is transparent for them, integrating not only with their day-today practices, but also with their views of mobility and accessibility as central to their way of life [8]. However, before this project, even if their personal handsets supported a variety of features such as e-mailing, surfing the Internet, calendaring, and so forth, most participants used their phones only for making ordinary voice calls or for receiving/sending SMS. Generally, students' attitudes toward the services improved when they could start choosing the channels of their preference. Students perceived MUSIS mobile services as something useful, dynamic and integrated in their every day life.

Did students find mobile phones and multicasting useful for learning?

Participants were more likely to see the multicasting service as useful the more it was integrated into their course content. The two courses in this study differ substantially in how the instructor used the technology. One instructor (for MEA708, in the School of Mathematics and Engineering) did not adapt his assignments or activities for the technology. The other (for GIX 131, in the School of Humanities), actively produced content for this medium. In addition to sending a relatively high number of MUSIS messages (41) to students, seven were multimedia in form (video and audio).

The importance of integrating the service into the pedagogy or instructional style of the course is illustrated in Table 1, which reports results from the survey item, 'How useful did you experience the course related information sent to the educational channel?' In both classes, the majority of students saw the educational multicast services as useful or very useful in week 5. However, by week 10, that figure had dropped to less than 50% for MEA708. At the same time, the number of students in GIX131 viewing the services as 'very useful' grew substantially.

With regard to usability and functionality of the phone itself, participants reported dissatisfaction with the small size of the mobile phone buttons, the quality of video, the small screen size and problems with video and audio getting out of synch.

Results from School of the Humanities: Fundamentals of Swedish Language and Literature

Students in this course are training to be upper secondary school teachers. During the time of the MUSIS project, the course focused on grammar, phonetics, text analysis and language history. Content was delivered through weekly lectures, complemented by a First Class (FC) web conference discussion forum. The FC forum was used on a daily basis by both teachers and students for publishing documents (text, audio as well as video), discussions (mostly questions and answers regarding the trickier parts of the course) and also for signing up for exams and forming study groups.

Table 1. Perceived usefulness of the educational mobile services after 5 weeks (n=41) and 10 weeks (n=41)

Course	Week	Very Useful	Useful	Fairly Useful	Not Useful
GIX131	5	27.3%	45.5%	18.2%	9%
MEA708	5	10.5%	52.6%	21.1%	15.8%
GIX131	10	40%	26.7%	20%	13.3%
MEA708	10	5.9%	35.3%	41.2%	17.6%

Fifty students enrolled in the course, and 22 were given smart phones as part of this project. All students had access (either by computer or smart phone) to the same course information generated by the instructor, which was published to the web on FirstClass. We did not deliver student messages because we judged that the quantity of them would be perceived by the students as mobile phone spam. Interviews with students confirmed this judgment; students reported they wanted only information from the instructors.

Overall, students in this course responded positively to the use of MUSIS messages. This seems to be due to two major reasons. First, easy access to the instructor and to course materials was particularly important, because students were off campus 4–5 weeks each semester, on site in schools. The constant presence of the phones in pockets and handbags meant that course information could reach the participants instantly. For example, the teacher sent out a number of grammar exercises and 'micro lectures' about syntax analysis. Our interviews and final workshop revealed that students found these messages useful. One student stated 'A funny way to get information about "boring" things (syntax analysis)', while another student said 'It is easier to understand when someone explains it instead of reading it yourself'. The students valued course-related information, e.g. schedule updates and the short, effective videos containing audio as well as text, sent before exams and lectures. Second, the pedagogical style of the instructor fitted well with the values of communication and mobility offered by the phones, a fact confirmed by feedback from the final workshop. Most students claimed that the teacher's use of audio-visual materials was very important for bringing interesting content and adding value to the smart phones. The instructor sent seven multimedia messages related to assignments, course readings and project reports.

An unexpected finding came from an assignment that the instructor developed specifically for the smart phones. Students were given a question and had to answer through an audio recording of about one minute, produced with the phone. Contrary to our expectations, students spent a great deal of time staging and composing their answers, often recording multiple 'takes' before the final project was sent in. Preliminary analysis of

the students' recordings show that they seek to compress information by concentrated, effectively expressed sentences rather than by indistinct, fast talk. This finding mirrors the common practice in e-mail of composing messages rather than using the abbreviated language and casual exchanges of SMS.

Analysis of results from final workshop

The MUSIS final workshops at VXU were held at the end of May with twenty-two students from courses GIX131 and MEA708 participating. The aim of the workshops was to gather information about how the students experienced the services during the trials, their impressions and patterns of behaviour, as well as their suggestions for improvement to any of the services. Two members of the MUSIS team at VXU were responsible for conducting the workshops. The workshops were videotaped and transcribed. The results of the workshops contain many details that are useful and that should be collected as project leaders continue to develop the product and the service. For example, there are several responses relating to usability and interface. For the most part, users agree regarding the ways in which services can be improved; for example, improve the quality of the video, improve channel subscription, improve the way messages can be received. We found tensions in three main areas, in which user opinions are fundamentally at odds with one another. Resolving these issues is problematic, because it means choosing one user viewpoint over another.

Tension 1: Users as 'students' and users as 'consumers'

By mixing different kinds of services and different kinds of information, the phones are not only educational technology and not only media devices. They are both. But students have very different expectations for media services (like news or entertainment) than for educational services (like lectures or assignments). Usually, students are much more forgiving of educational content. It does not have to be of as high a quality, or as consistent and dependable as news, TV, or movies. We found that participants in these workshops begin to blend these expectations. This will have important implications for teachers adopting this successfully for use in their courses and assignments, as students will not be as forgiving of low production quality.

Tension 2. MUSIS as 'content' and MUSIS as a 'device'

One group of users in the workshops found the quality of information delivered by MUSIS to be most important. These are students who focus on the content that they could access through the phone, talking mostly about the quality and value of the content. They like getting unique information, such as lunch menus. They are concerned with how often messages are delivered and how easy they are to access. They are also most likely to have a strong opinion about different subscription levels; they are more concerned about the quality of the device. These are users who don't pay as much attention to whether the information is unique or good. They think of the phone as a media player: how does it compare to TV, computer, or PDA? They are more likely to focus their comments on whether the phone is easy to carry, or on the size of the screen, or the quality of the audio. They are less likely to pay for the service if they don't see the device as necessary. The existence of these two groups suggest that in developing MUSIS, we need to think about these needs as somewhat independent of each other—better information won't make the second group more satisfied, and a better device won't make the first group more satisfied.

Tension 3. Wireless multicasting as 'possibilities to be fulfilled' and wireless multicasting as 'expectations to be violated'

Any robust technology moves from experiment and innovation to the long-term stage of stability and dependability. The transition between these can be dangerous for any new technology. There is evidence from these workshops that MUSIS is in this transition. Several users are willing to forgive the difficulties and problems with the technology because they see it as still being in an experimental stage. They talk about the possibilities of new services and new functions. They are not looking at the current so much as they are to the future. But a surprising number of users do not share this view. They expect the services and functions to be much more stable and dependable. They are less likely to experiment and try new uses. When the service doesn't work, they are more easily frustrated and more likely to abandon it. The design challenge, therefore, is how to both continue to experiment and develop new aspects of the technology without alienating users. It may be time for development to split into two streams: one concerned with establishing the reliability of the platform while the other continues to expand new services and functions.

CONCLUSIONS AND FUTURE DEVELOPMENT

In this paper we illustrated a number of educational mobile services used by students in a university environment and discussed the patterns of use of these services on campus and other locations of their choice. Impact on learning itself was not measured, nor would it have been possible to measure meaningfully when the devices were used for such diverse purposes. Phone-optimized content was well used, and there was a clear request from students that more resources be made available in this format, including adminis-

trative information from the University. There is no conclusive evidence of the need for a specifically designed suite of tools in addition to those already included in the device, although students would like to send multimedia material of larger size than that allowed on an MMS.

Ownership of the technology is clearly important. As long as the phones are loaned, students are reluctant to invest time and money in personalization and extension. Despite this, several of the students were able to see future benefit in the devices as learning aids; they invested time as part of their course activities in thinking about new services that could be developed. Because students received music, video clips and other content, smart phones are likely to become more embedded in their lifestyle.

Greater institutional support is needed in order for the smart phones to be used more fully. Regular updates of timetables and content, as well as adequate training and hardware provision are needed. As more students bring the technology with them to the university, change will most likely be driven by their demands as consumers. It has been shown that the smart phones used in this study did not generate a radical change in students' styles or patterns of learning. As smart phones become a more intrinsic part of everyday life, it is important that these patterns and demands are known and understood.

Students in the MUSIS project were experiencing a number of services that have been designed to facilitate the accomplishment of everyday activities, including knowledge work. These services were constantly tested in order to assess their functionality and usability, and users were involved in the design process. MUSIS services were delivered in a simple, user-friendly way and were accessible almost everywhere. This particular feature of MUSIS may be one of the reasons for the high acceptance of the services. All mobile services related to course information, video micro-lectures and scheduling issues were highly ranked among users and they were perceived as very useful in supporting their daily activities, both social and intellectual. Regarding the project partners, their image of MUSIS is totally different. For the content providers, MUSIS was an innovative testbed for experimenting with new ideas and concepts that may lead to future sources of revenue. For TeliaSonera and Bamboo MediaCasting, who represent the telecom sector, MUSIS has been a platform for testing new technology and business models for future mobile services.

Our results confirm the importance of designing applications and services for learners that are easy to use 'on the road', that could be completed in short bursts of time [9]. Educational mobile services are one way to support what Brodersen and colleagues call 'nomadic learners', who are more project orientated and who send much of their daily life 'in transit between many physical places ("oases") such as classrooms, labs, workshops, libraries, museums, the city, nature, clubs and at home' [10]. However, our results also suggest that, in higher education, a challenge is designing content appropriate for 'perpetual contact' [11] between the student and the instructor.

Feedback from students showed that there is a clear need for providing institutional support of educational mobile services; in particular, course-related content and timetabling information. Usability issues relating to the smart phone and the different contents had considerable impact on the students' experience and satisfaction regarding the smart phone and the mobile services. This was also a first attempt at designing educational mobile services. Further designs are underway and are being shaped by the findings of this trial. During the last autumn term we continued with the trials in the context of the GIX131 course and we incorporated two new additional courses with 30 Media Technology students. The results of these new trials are still under analysis and they will be reported in future publications.

As our work continues, we will try to enhance the educational aspects of the mobile services by developing and implementing various solutions to specific problems we have identified based on our observations and the data we have collected from the students. Our future efforts will continue to refine both the technology and activities for providing learners with more meaningful experiences with regard to the use of smart phones in university settings.

Acknowledgements—The MUSIS project has been partially funded by governmental bodies— Swedish VINNOVA and Israel's MATIMOP—as part of the SIBED programme, a joint Swedish-Israeli mobile technology research effort. This document does not represent the opinion of VINNOVA and MATIMOP, and these agencies are not responsible for any use that might be made of the data appearing therein. We thank all the MUSIS team members, especially Fredrik Alserin and Jonas Gustafsson at VXU for their efforts in connection to the design and implementation of the software components and tools described in this paper.

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