Mobile Message Services Using Text, Audio or Video for Improving the Learning Infrastructure in Higher Education

B. Hedin[1]
[1] KTH/CSC/Department of Media Technology and Graphic Arts, Stockholm, Sweden

Abstract— **This study examines how media files sent to mobile phones can be used to improve education at universities, and describes a prototype implement of such a system using standard components. To accomplish this, university students were equipped with mobile phones and software that allowed teachers to send text-based, audio-based and video-based messages to the students. Data was collected using questionnaires, focus groups and log files. The conclusions were that students preferred to have information and learning content sent as text, rather than audio or video. Text messages sent to phones should be no longer than 2000 characters. The most appreciated services were notifications of changes in course schedules, short lecture introductions and reminders. The prototype showed that this functionality is easy to implement using standard components.**

Index Terms—**advance organizers, m-learning, mobile education services**

I. INTRODUCTION

The research objective within the EU/IST Work Programme is defined as "improving the efficiency and cost-effectiveness of learning, for individuals and organizations, independent of time, place and pace" [1]. While computing technology has been shown to have a positive effect on learning [2], and e-learning is now well established, we are still far from the EU/IST vision of learning independent of time and place. For this vision to become true, the only technical platform currently widely available is to use mobile phones, something almost all students have and carry with them at all times.

Education seen from a holistic point of view is not only about the actual "learning". The whole learning environment must be considered; teaching, learning and the infrastructure that makes learning possible. Administrative tools, such as deadline reminders and easy access to course schedules can help students focus on learning instead of other tasks, and contribute to the overall quality in the education. According to Biggs [3], this is one of the areas in which educational technology excel. Inferior infrastructure can be the cause of discontent and unmotivated students, which is often reflected in course evaluations. Therefore, examining how mobile services can be used to improve the learning infrastructure is as important as how mobile services can be used directly for learning. This can also be a first step towards introducing m-learning technology to a wider audience.

The main purpose of this paper is to examine how text, audio and video messages sent to mobile phones can be used to improve or enhance education at universities, and to discover which mobile services students want. The secondary purpose is to examine how to implement such a system, using simple, standard technology. The intention is not to provide entire courses on mobile phones, but rather to provide services to complement regular courses. The core technologies in the courses remain textbooks and lectures, and the contents provided on mobile phones are what Collins and Moonen describes as "complementary" [4].

The research questions can be summarized as:

- What mobile education related services do students want?
- Which mobile media format is preferred, given that technical and economical obstacles are solved?
- How can a simple, usable system based on the results of the first two research questions be implemented?

Of particular interest was to investigate what the students' attitudes were to receiving, what Ausubel named, advance organizers [5] sent to their phones before lectures. Advance organizers are short "introductions" of topics, which can help students assimilate learning material into their cognitive structures. Instead of being unprepared, a basic cognitive framework exists to which the content of the lecture can be related. Advance organizers are originally intended for preparing reading of text-based content, but we extend their use to preparing for lectures.

Another area of interest was to provide ways for students to revise course content at unforeseen times, such as when waiting for a bus, since rehearsing and recalling is important in the process of transferring information from short term to long term memory. Thornton and Houser [6] reports success for learning vocabularies by sending vocabularies to the mobile phones of Japanese university students. The students who were urged to study vocabularies sent to their phones learned more compared to students who were urged to study the same material on paper and web, and the students also preferred receiving the lessons on their phones rather than on their PCs.

One possible cause for Thornton's observations of increased learning could be that studying for several short moments instead of one longer moment might be beneficial for successful memorization, based on the serial position effect, which can be broken down into the primacy and recency effects [7]. The primacy effect means that the mind, if presented with a series of stimuli or observations, remembers items presented near the

beginning, and the recency effect means the mind remember items presented near the end. Combined, they mean items presented first and last are more likely to be remembered, and items presented in the middle are less likely to remember. Studying several shorter sessions, such as spare moments when traveling to or from the university, rather than one longer session means more time is spent near the beginning or the end of the session. It is therefore reasonable to assume that this is a better strategy for memorization, given the total time studying is the same.

This is supported by Sandberg [8], who means that the probability of successful learning increases substantially if you repeat what you want to learn at odd hours, when traveling, when waiting for a bus or at other free moments. More support for this can be found in the field of neuroscience, where spaced repetition increases the synaptic connections required for conversion of short-term memory to long-term memory as shown by Pinsker et al., Carew et al and Frost et al referenced in Kandel [9]. However, as pointed out by Baddeley [10], just repeated rote rehearsal does not necessarily lead to long term retention, unless some form of deeper semantic processing or elaboration takes place. Also, there is a difference between memorizing facts and deeper learning, where memorization occupies the lowest level of Bloom's taxonomy for educational objectives [11], but most university education aims at the higher levels of analysis, synthesis and evaluation. Therefore not just learning content was sent in this study, but also material where students had to reflect on the course content.

II. METHOD

The study consisted of three phases. The first two phases were parts of the MUSIS project[1], and the third phase was a continuation carried out at KTH. The test group in phase one consisted of one class of 18 students (9 male, 9 female), participating in the course 2D1553 Media Production[2] during October – December 2004. 14 of the students had a technical background, having studied three years on a masters programme at KTH. The remaining four had a background in economics, having studied two years at Stockholm School of Economics. The test group in phase two were 16 of the students from phase one, taking the course 2D1555 IT and Organizations[3] during March – May 2005.

In these two phases, the students were provided with Nokia 6600 SmartPhones, with Symbian operating system, 128 MB memory and a 167x208 pixel display with 65.536 colors. The phones were equipped with special software and subscriptions to receive text, audio and video messages sent by the teachers. In phase tree a prototype, based on the results from these two phases, was developed. This prototype could only deliver text-based content, but did not require additional software to be installed on special phones. The prototype was tested for sending course related messages to students in two programming courses, with different participants than in phase one and two. The first of these courses had 34 participants (21 male, 13 female), mainly students in the fourth year of the M.Sc. programme in media technology at KTH, and the second had 19 participants (15 male, 4 female) studying the third year at the bachelor programme in media technology. The messaging service in this final phase was just presented to the students as new information channel, which the students could use if they liked.

During phase one, data was collected using questionnaires answered by all students, and focus groups, where the students in groups of four or five discussed their experiences for two hours with three members of the MUSIS project group who took notes. During phase two, log files indicating when students actually read text messages were added, and all text-based messages included a form where the students could give immediate feedback about the perceived value and length of the message. The focus group meetings after phase two were video recorded and transcribed.

Phase three mainly aimed at developing and testing a software prototype, as described in section 3.2, and the only formal evaluation of the students' usage of the prototype was a basic analysis of the log files generated.

III. TECHNOLOGY AND SERVICES

A. *Phase one and two*

The MUSIS project platform can deliver rich media content to large groups of users over the existing GPRS/EDGE/UMTS[4] networks. A client application running in the background is installed on a phone, and the phone number is registered for the service. The user can then choose to subscribe to any of a number of pre-defined channels. A channel has a theme like news, music, entertainment, fun or education. When a publisher adds new content to a channel, the clients subscribing to this channel are notified and downloading of the content starts

Figure 1. The MUSIS client interface

[1] Multicasting Services and Information in Sweden, http://www.musis.se/

[2] http://www.nada.kth.se/kurser/kth/2D1553/afmmep04/

[3] http://www.nada.kth.se/kurser/kth/2D1555/afmitorg05/

[4] GPRS, EDGE and UMTS are mobile telecommunication systems for packet-based transmission of data.

in the background. When the download is complete, the user is notified there is a new message, and the message title and channel icon are displayed in the inbox of the client application, as shown in Figure 1. If the user clicks on the message icon, the content is immediately shown or played in the phone's external applications, RealPlayer for video content, the audio player for audio content, the web browser for web pages and an eBook reader for eBooks. In this trial there was a size limit of 500 KB per message, putting limits on video and audio content, both in terms of length and quality.

In the first two phases, one channel was used to send course related messages. This channel was used to send short text introductions about upcoming lectures, similar to Kloster's outline organizers [12]. These are a version of advance organizers, in our case consisting of an outline of the content to be learned in the lecture. The channel was also used for messages about deadlines, reminders and instructions for how to prepare for the lecture (i.e. chapters to read, assignments to do, problems to consider). Finally, more complete course materials, like PowerPoint slides, were sent after the lecture. All course related messages, except three messages that were video based, were also sent by email to all students. This allowed us to compare mobile messaging to traditional email-based course communication. The trial also contained several other channels, such as fun, music and lunch menus. However, these are not evaluated in this paper except as a reference for how interested students were in educational mobile services compared to mobile services aimed at a more general public.

B. Phase three

After the first two phases were completed, a prototype was developed based on parts of the results obtained. The goal for this prototype was to make an implementation of a system for sending longer text based content to students' mobile phones. The prototype should be usable in regular courses given that students have mobile phones capable of rendering XHTML[5] web pages and that the course administration has access to an SMS[6] gateway. The implementation should be easy to use for the course administrators and should not be expensive to use for the students.

The prototype consisted of two parts. The first part, shown in Figure 2, covered sending course related messages to the students. The main features for the first part of the prototype were:

- Course messages edited and sent using a LMS[7] or using ordinary email.
- Persistent storage of these course messages in a blog.
- Low cost, typically around ¢ 0.1 - ¢ 0.3 per message in data transfer cost for the students, and the cost of an SMS for the university.

Figure 2. The mobile adapted blog index and a blog entry

- Notification of new messages to phones by an SMS sent from the LMS.
- Multiple channel publishing of the blog content to a web version and a mobile version using XSLT[8] transformations.

Apart from the LMS with the SMS gateway, the solution only consisted of standard components available either as free services or as open source software. The teacher sent the message using an LSM. The complete message was delivered by email to the students, who also received an SMS with a link to an URL[9], which when clicked opened the phone's web browser with the mobile version of the message. The LMS also delivered the same email to a blog for the course, accepting postings by email. The blog was used for persistent storage of all messages, as well as being the "database" used to create the mobile adapted version. The mobile version, was generated by a simple PHP[10] script, which retrieved the RSS[11] feed from the blog. The RSS feed was used as an XML generator[12] for a web server with an XSLT module. The PHP script and an XSLT stylesheet dynamically generated a mobile adapted index page with the titles of all messages, linked to pages containing each specific message as seen in Figure 2.

The second part of the prototype, shown in Figure 3, allowed the teachers to, before a lecture, send the students "learning packages" of content related to the lecture. These learning packages consisted of four linked web pages, suitable for viewing on mobile phones. The four pages were a summary, corresponding to an advance organizer, a list of keywords, reflection questions and literature references. A slightly more complex scheme was used for creating and publishing these learning packages.

The main features for the second part of the prototype were:

[5] Extensible HyperText Markup Language, http://www.w3.org/MarkUp/
[6] Short Message Service, short text messages sent to mobile phones
[7] Learning Management System, i.e. Blackboard, WebCT and in our case PingPong
[8] Extensible Stylesheet Language Transformations, http://www.w3.org/Style/XSL/
[9] Uniform Resource Locator, a unique web address for a resource.
[10] PHP Hypertext Processor, a scripting language for making dynamic web pages.
[11] Rich Site Summary, a format for notifying clients of new web content at a web site.
[12] See http://cocoon.apache.org/2.1/userdocs/concepts/

Figure 3. A learning package consisting of a summary, keywords, review questions and literature references

- Editing of the learning package using an XML editor or word processor like OpenOffice, capable of saving content in an XML document format.
- Notification to the students of new learning packages by SMS.
- Low cost per message, similar to the cost in the first part of the prototype.
- Multi channel publishing of the content to PDF and a mobile version using XSLT.

The teacher wrote the learning package using the OpenOffice word processor, and then placed the resulting XML file on a web server. The notification was done in the same way as in the first part of the prototype, as an SMS containing a URL.

IV. Results

A. Phase one

After phase one, the students considered the most useful services to be the advance organizers and general course information, delivered by text. The questionnaires showed that the messages were mostly read immediately when the students received the message, but also before lectures. PowerPoint slides sent out after lectures were considered too difficult to read on small mobile phone displays. Audio and video formats were difficult to evaluate during this phase, since the students did not have headsets to their phones, thereby making it difficult to use content containing audio.

The focus group meetings after phase one ended with a brain storming session, where the students were asked to come up with MUSIS services they would be interested in. All 48 suggestions were collected and all students were then asked to grade the messages on a scale of 1 (bad) to 5 (good). 6 of the 48 suggested services, shown in Table 1, were related to education. These occupied 6 of the 7 top positions, with an average grade of 4.92, while only 3 of the remaining 42 suggestions got grades above 4.0 with a median value of 2.95.

TABLE I.
THE SIX EDUCATION RELATES MUSIS SERVICES SUGGESTED BY THE STUDENTS

Service	Avg. grade
Message when some information is available like exam results	5
Updated schedule after changes	5
Example of exam questions with answers	4.9
Tomorrow's schedule	4.9
Tomorrow's activities in a course	4.9
Project deadlines	4.8
Average	4.92

Of the six education-related suggestion, the two highest rated both concerned getting information when some event had occurred, such as when exam results are ready or when there has been changes in the course schedule. Four of the suggestions were about course information that could just as well be handed out at the beginning of the course, but the results from the focus group discussions confirmed that the students wanted this information sent to their phones as well. Two of the suggestions concerned learning, one being preparing for tomorrow's lecture and the other being sample exam questions based on the topics covered in the lecture.

Simplicity of the user interface was considered to be of key importance. Due to technical limitations, files of the MobiPocket eBook format[13] sent out required the user to save these files before opening them in the external MobiPocket reader application. This was considered to be too bothersome, causing most students to ignore these messages. The MUSIS interface, where all messages were presented in a time ordered list with a text based title and an icon as shown in Figure 1, just requiring one click was considered very good. Based on these experiences, all text-based content was sent as web pages during phase two, limiting the functionality compared to eBooks, but greatly simplifying the handling from the user perspective since these messages worked with the one-click interface.

B. Phase two

During phase two, log files of the exact time when students read text messages were generated. Another new feature were feedback forms included in all text messages, where student could grade their level of interest in the message and the length of the message. The text messages were viewed on an average 14.8 times each ($\sigma = 4.55$), by the group of 14 students[14] participating in the second course. This does not necessarily mean that each message

[13] E-books in a format readable on mobile phones, http://www.mobipocket.com/

[14] Two of the sixteen students had technical difficulties with their phones, and are therefore not included.

TABLE II.
INTEREST IN MESSAGES SENT IN THE COURSE CHANNEL IN PHASE TWO. 98 MESSAGES WERE SENT AND 50 REPLIES RECEIVED.

Level of interest	Very	Fairly	Moderately	Not
Frequency	50%	34%	6%	10%

was viewed by each student, since a log file entry was generated each time a student read the message, meaning one student reading the same message several times would generate several log file entries. Feedback was supplied on an average 6.11 times per message (σ = 3.78), showing that 50% were "very interested", and 34% "fairly interested" in receiving such messages on their phones, as shown in Table 2. The focus group meetings, and a parallel study in Växjö [13] within the same project gave similar results.

The average length of the text messages, shown in Table 3, were 1769 characters, white space included (σ = 632). Five of the messages were short (444-850 characters), and seven were long (1450-3297 characters). 11% of the instant feedback replies for the shorter messages consider them to be too long, and 40% of the replies for the longer messages considered these too long. The reply frequency of 46% could give rise to fears that the remaining 54% was correlated with not reading the entire message, thus not even reaching feedback form at the end of the message. However, the reply frequency was probably higher, since technical difficulties caused some messages not to reach all participants. The results from the focus groups also showed that the general length of the messages were considered to be "good, but could be shorter". Message M17, for which all students gave feedback, also indicated the same result.

Each "reading event" was logged, making it possible to see the time the messages were read compared with the time they were sent, as shown in Table 4. 28% occurred within one hour, another 34% within one day, another 24% within one week and the final 14% after more than one week. An interpretation that is also supported by the questionnaires and focus group meetings is that messages were first read as soon as possible, but sometimes also later read when readers had nothing else to do.

Another interesting topic is messages related to upcoming real world event, like a lecture. We wanted to investigate if students used time when traveling to the university to prepare for today's lectures by reading the lecture introductions, as was indicated after phase one. The messages were sent 4-5 days before the lectures, giving the students opportunities to read the content both immediately, and just before the lecture. However, only 5% of the reading events occurred within one hour before the lecture, and another 3% within one day before the lecture, indicating that most students didn't study on their way to the university. The results from the questionnaires indicate the same, where only 5 of 18 students replied that they usually study between one and three days per week when traveling to the university. 5 students didn't use public transportation at all, instead walking or using bikes, which would explain why they didn't study on their way to/from the university. The results focus group meetings indicated that advance organizers for a lecture, should be sent out after the previous lecture in the same course, but no earlier than 4-5 days before the lecture.

TABLE III.
STUDENT OPINIONS ABOUT TEXT MESSAGE LENGTH. 182 MESSAGES WERE SENT AND 83 REPLIES RECEIVED.

Channel	MSG id	Length	Too long	Good	Too short
Course	M17	1700	5	9	0
Course	M24	1548	2	2	0
Course	M28	1459	4	2	0
Course	M32	1450	0	2	0
Course	M33	3297	2	1	0
Course	M35	1731	2	7	0
Course	M38	1629	3	4	0
Info	M29	841	0	6	0
Info	M30	10554	1	1	0
MUSIS info	M37	675	0	8	1
Entertainment	M39	592	3	6	0

It was clear, both from the questionnaires and the focus groups, that the preferred media format was text. It was considered easier to skim through text information than audio or video. It was also considered difficult to hear what was said in audio based messages, even in moderately noisy environments, and the students felt it was a bit "geeky" to watch education videos at trains or buses. The questionnaires showed that 66% of the students preferred text after phase one, and 92% preferred text after phase two. This should also be seen in the light of the bias caused by the students not having headsets during phase one, making the results from phase one more an indication of what they thought their attitude to sound and video were, and the results from phase two more based on their actual experience.

The students liked to get course related information sent to their phones. To immediately be notified of new information was considered to be the greatest strength of mobile phones. Getting the same information by publishing it on, for example, web site viewable on mobile phones was considered much less attractive since that would require the students to repeatedly poll the content of several web sites. Getting the information to the phones was also better than by email. The main reason for this was because there is no delay, compared to email where the student has to have access to a computer. Another reason was because they always have access to both old and new messages and can check them anytime, since they always carry their phones with them. However, for

TABLE IV.
TIME WHEN MESSAGE WAS READ RELATIVE TO WHEN SENT (N=74)

MSG ID	M28	M32	M33	M35	M38	Total
<1h	3	2	1	6	9	28%
>1h,<1d	9	2	4	4	6	34%
>1d,<7d	3	3	5	5	2	24%
>7d	2	1	3	1	3	14%
Total	17	8	13	16	20	100%

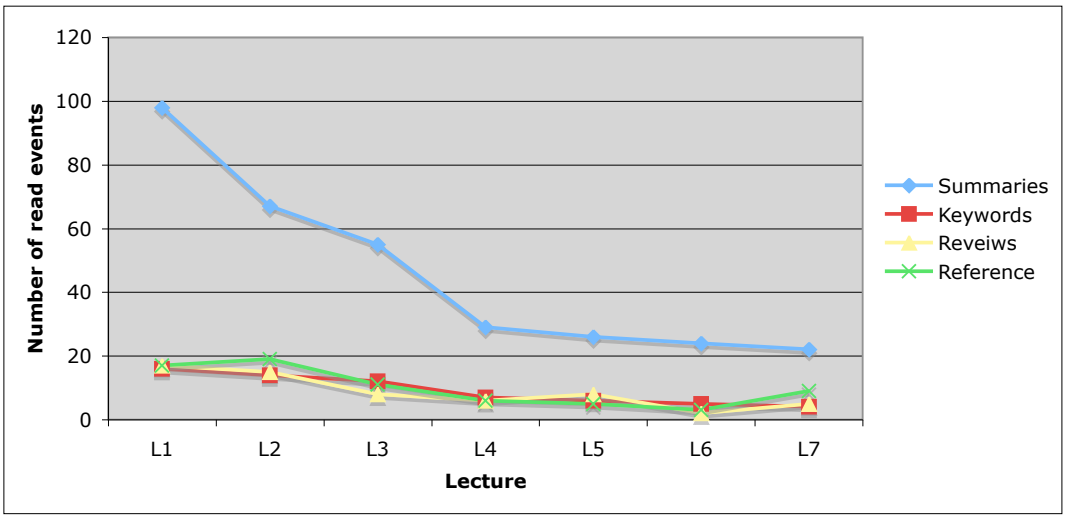

Figure 4. Total number of read events for each category per lecture

more general messages, like fun video clips or news, pull was considered better. It was considered important not to get too many messages, especially if the messages were considered unimportant.

Notable is that the students liked to get messages with course information close to corresponding events in the course, even if the same information also was distributed at the beginning of the course. This confirmed the results from the brain storming session after phase one, where services like reminders were highly appreciated. They wanted the information and reminders "just in time". This coined the expression "virtual nanny" in the project group, as a service where the students were reminded of what to do, where to go, and what to read each day.

The students wanted a web-based portal where all messages they received were stored as backup. This was important since it was not possible to keep all messages on the phone, and sometimes the need to go back to old messages could occur.

The students were asked how much they would be willing to pay for a service with course related content sent to their phones during the courses. Many students agreed that they would be willing to pay around € 2 per month for such a service if supplied for all courses, but some would not be willing to pay anything. The cost for the data transfer today in Sweden is about € 2 per megabyte[15], which would mean that a maximum data traffic of 2 MB per month. If flat rate fees for data traffic are used, a price model some operators now begin to introduce[16], the variable cost would decrease to zero.

C. *Phase three*

The prototype developed for phase three worked quite well, both from a technical and a user point of view. There were some problems with sending clickable links by SMS, since some phones could not open the URL directly by clicking on the link, and instead the entire URL had to be entered manually. When this was discovered, the workflow was modified, so the students added the URL to the index page as a bookmark in their mobile phones web, and could go to that bookmark when they received an SMS about new course information. An alternative could be to use WAP push[17] which would solve this problem, but that would require a more complex SMS service from a technical point of view.

3 out of 14 phones that connected to the service were unable to render XHTML web pages, but this problem will disappear within a few years due to the development of mobile phones.

In the course with 34 students, 7 students read 2 or more of the 7 learning packages that were sent on their mobile phones. However, only the summary pages were read, not the keywords, references or the reveiw questions.

The links to the learning packages were also sent by email, making it possible to observe the students' usage of the learning packages from their computers' web browsers. As seen in Figure 4, the summaries were also the parts of learning packages that were read most frequently when the learning packages were viewed from a desktop computer. Each summary was viewed on an average 45.9 times with web browsers throughout the course (σ = 28.8), while the keywords, review questions and references were viewed on an average 9.3 times each (σ = 5.2). As seen in the figure, there was a steady decline in reading the learning packages as the course progressed, accounting for the high standard deviation. One reason for this could be decreased enthusiasm about the service, but another contributing factor could be that the course was assessed mainly on content in the earlier lectures.

If, instead of looking at absolute values, we look at the relative values for how often each of the four sections of each learning package was read, we see a clear pattern between the different sections within the packages, as shown in Figure 5. The summaries accounted for 62% of the reading events (σ = 5%), keyword for 13% (σ = 2%), reviews for 12% (σ = 2%) and literature references for

[15] http://www.tre.se/templates/SubscriptionPlan.aspx?id=12784, accessed 2006-03-03

[16] €20 per month, http://www.tre.se/templates/SubscriptionPlan.aspx?id=19439, accessed 2006-03-03

[17] http://developer.openwave.com/docs/wappush_vs_sms.pdf, accessed 2006-03-03

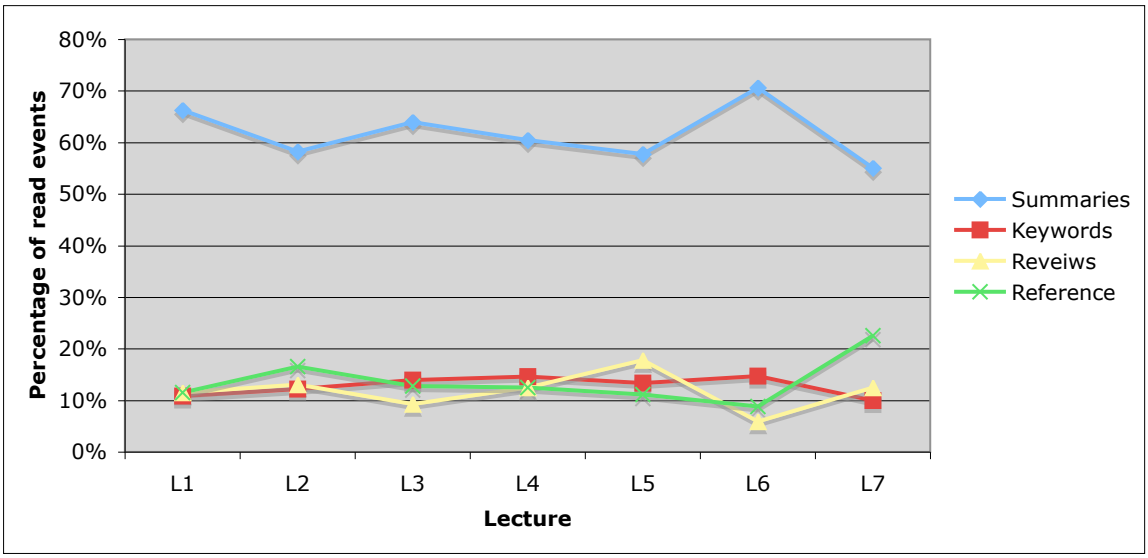

Figure 5. Relative frequency of reading summaries, keywords, reviews and references within each package

14% (σ = 5%). One reason to explain the apparent popularity of the summaries is that the links in the emails pointed at the summary in each package. Some students might have clicked on the link in the email generating a log entry for the summary, but not explored the content of the package further. Also, some may have used the emails as "bookmarks", thereby navigating to the summary on their way to one of the other pages in the learning package.

43.2% of the read events occurred before the lecture and 56.8% occurred after the lecture, showing that students used the packages both to prepare for the lecture and for repeating what the lectures covered.

Comparing the use of mobile phones to desktop web browsers for accessing the content shows that 10.4% of the read events were from mobile phones and 89.6% from desktop web browsers. This clearly indicates that the majority still preferred to read material on desktop computers.

V. Discussion and Conclusions

The first research question in this study was which mobile education related services students want. The brain storming session after phase one, and the evaluation of the provided channels, showed the student had a very high general level of interest in educational related services on their mobile phones, even when compared to services that we expected would be popular, such as news and music. The most appreciated service would be notifications, for example when there are changes in the course schedule, which was not surprising.

More surprising was the high level of interest in reminders of events and deadlines, which the students also are informed of at the beginning of the course. Implementing such a system would be relatively easy from a technical point of view, but would be difficult from an administrative angle. Who should decide a suitable time for sending reminders? When should a reminder for a project deadline be sent? Will the students expect to be instructed on when and how to study from now on?

Of the services related to learning, receiving advance organizers before lectures was popular, but the results from phase three showed that most students still choose to view these on a computer screen rather than on a mobile phone if given the choice. The hypothesis that students would use free moments to review learning content did not gain support.

The second research question concerned what media format the students wanted for mobile education content. The results clearly showed that text, with a maximum length of about 1000-2000 characters, was preferred even without considering possible technical or economical issues. In a less controlled environment, technical difficulties such as different media support in different handsets, and economical issues such as the high cost of transmitting audio or video in an environment with the current tariffs for data traffic, would make text even more suitable. A final argument against audio and video is the higher complexity for the teacher of producing audio or video content compared to text-based content.

However, the students' negative attitude towards video and audio should be interpreted cautiously, since both the video and audio content was of relatively poor quality due to the file size limits. With more modern handsets with better audio and video capability, and with flat rate pricing for data traffic allowing larger file sizes, audio and video could be more attractive. Podcasting could also be an alternative to distribute video and audio based material without having to pay for data transfer costs in the mobile networks.

The third research question was how to implement a simple, usable system based on the results of the first two research questions. Our proposal, with a simple system using standard web technology combined with SMS notifications proved highly successful. The system requires no extra work for the teacher, and no special hardware or software for the students other than a reasonably modern mobile phone. An extra benefit was the possibility to produce PDF versions of learning content using XSLT technology.

In future research, we intend to test the prototype in more courses during a longer time period, making it possible to measure the students' attitudes towards such services once they have become more accustomed to them. Another interesting topic is to find alternative ways of presenting text, which could increase the acceptable amount of text beyond 1000 – 2000 characters. Two such technologies are RSVP, Rapid Serial Visual Presentation [14] [15] [16], where words are displayed rapidly in a sequence, and Times Square where the text scrolls over the screen from right to left [17] [18]. Both these technologies are suitable for presenting text on small displays. Finally, examining the effects of studying in fragmented time is an interesting topic, requiring more studies.

In summary, the recommendations from this study are to use text based messages sent by to students, especially for notifications of changes. Message length should be no more than 2000 characters. A simple system to use, both for teachers and students is easy to implement. Comprehensive learning material will not be used by students, but advance organizers are much more useful. Still, it is hard to compete with a book when it comes to mobile studies.

REFERENCES

[1] Speiser, M. (2006): Research objectives in FP6. European Commission [online]. [Accessed February 16th 2006]. Available from World Wide Web: <http://www.cordis.lu/ist/telearn/goals.htm>

[2] Norris, C.; Soloway, E.; Sullivan, T. (2002): Examining 25 years of technology in U.S. education. Communication of the ACM, Vol. 45, No. 8, pp. 15-18.

[3] Biggs, J. (2003): Teaching for quality learning at university. Berkshire: Open University Press.

[4] Collins, B.; Moonen, J. (2001): Flexible learning in a digital world. London: Koogan Page.

[5] Ausubel, D.P. (1960): The use of advance organizers in the learning and retention of meaningful verbal material. Journal of Educational Psychology, Vol. 51, pp. 267-272.

[6] Thornton, P.; Houser, C. (2004): Using Mobile Phones in Education. Proceedings of the 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2004), 23-25 March 2004, Taoyuan, Taiwan. IEEE Computer Society 2004, pp. 3-10.

[7] Healy, A. F.; Havas, D. A.; Parker, J. T. (2000): Comparing serial position effects in semantic and episodic memory using reconstruction of order tasks. Journal of Memory and Language, Vol. 42, pp. 147-167.

[8] Sandberg, A. (1999): Minne, minnesteknik och studieteknik [online]. [Accessed February 22nd 2006]. Available from World Wide Web: <http://www.aleph.se/Projekt/Handbok/Minne.html>

[9] Kandel, E. R. (2004): The Molecular Biology of Memory Storage: A Dialog Between Genes and Synapses. Bioscience Reports, Vol. 24, Issue 4 - 5, pp. 475 - 522

[10] Baddeley, A.D. (1983): Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, Vol. 302, No. 1110, Functional Aspects of Human Memory, pp. 311-324

[11] Bloom, B.S. (1956): Taxonomy of Educational Objectives, David McKay, New York, NY.

[12] Kloster, A.M.; Winne, P.H. (1989): The Effects of Different Types of Organizers On Student's Learning From Text. Journal of Educational Psychology, Vol. 81, No. 1, pp. 9-15.

[13] Milrad, M.; Jackson, M.; Bergman, D. (2005): Exploring the Potential of Multicasting Mobile Services to Support Learning and Communication in University Classes. IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'05), pp. 107-111.

[14] Forster, K. L. (1970): Visual perception of rapidly presented word sequences of varying complexity, Perception and Psychophysics, Vol. 8, pp. 215-221.

[15] Juola, J. F.; Ward, N.; McNamara, T. (1982): Visual Search and Reading of Rapid Serial Presentations of Letter Strings, Words and Text. Journal of Experimental Psychology: General, Vol. 111, No. 2, pp. 208-227.

[16] Masson, M. E. J. (1983): Conceptual processing of text during skimming and rapid sequential reading, Memory and Cognition, Vol. 11, pp. 262-274.

[17] Kang, T. J.; Muter, P. (1989): Reading Dynamically Displayed Text. Behaviour & Information Technology, Vol. 8, No. 1, pp. 33-42.

[18] Juola, J. F.; Tiritoglu, A.; Pleunis, J. (1995) Reading text presented on a small display, Applied Ergonomics, Vol. 26, No. 3, pp. 227-229.

AUTHORS

B. Hedin is with the Royal Institute of Technology, School of Computer Science and Communication, Department of Media Technology, Stockholm, Sweden (e-mail: bjornh@kth.se).

Manuscript received 01 May 2006.