Experiences Obtained with Integration of Student Response Systems for iPod Touch and iPhone into e-Learning Environments

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Abstract; A new type of Student Response System (SRS) based up on the latest wireless technologies and hand held mobile devices has been developed to enhance active learning methods and assess students' understanding. The key services involve a set of XML technologies, web services and modern mobile devices. A group consisting of engineers, scientists and instructors with pedagogical competence, from seven European countries has designed the services. The new SRS provides intuitive control interfaces, which an instructor quickly learns how to use, provides more flexible and cheaper response services than existing on-site technologies based upon so-called "clickers", since it uses the Wi-Fi or mobile network to provide responses from students. The technology may be used for in-class, laboratory and distance training purposes, the latter being an entirely new option in SRS technology. We report experiences from using this SRS technology in physics teaching in engineering classes, as well as in distance learning in Europe.

Keywords: student response system, iphone and ipod touch, e-learning, blended learning, voting systems, polling systems, clickers

1. Introduction

Excellent teachers provide more than just lecturing. They organize the curriculum into an educational system, by establishing a suitable learning environment where tasks and assessments are integrated in order to encourage certain study paths. Learning results are obtained through stimulating, enjoyable and engaging lectures. Even in large classes the teacher should, from a practical point of view, manage to adapt his/her teaching methods based upon students' responses. These include both misconceptions as well as conceptions within the subject domain. One way of using technology from learning centered approaches to achieve responses from a class is by using a Student Response System (SRS). Research shows that teachers and students perceive SRSs to be beneficial, though evidence of improved learning has been less clear (Dangel & Wang 2008).

SRSs have been used for many years, typically in large classes to increase the level of students' involvement and learning. In literature SRSs may have many different names, such as clickers, personal response systems, audience response systems, and classroom response systems. SRSs are technology products designed to support communication and interactivity in classes (Beaty 2004). The technology allows an instructor to present a question or problem to the class, and receive answers from the students through a response device. A summary of all answers is presented for the teacher and the students to see. In other words, SRS is a communication system that allows the teacher to collect and analyse large amounts of data and through this investigate whether learning has taken place (Conoley 2005). Research shows that such systems have the potential to facilitate several classroom processes such as participation (Horowitz 1988; Dufrense et al. 1996; Trees & Jackson 2007), collaboration (Mazur 1997; Crouch & Mazur 2001), physical activity (Masikunas et al. 2007), cognitive involvement (Draper & Brown 2004) and self-assessment (Boyle & Nicol 2003; Stuart et al. 2004).

A traditional SRS generally includes a receiver for instructors, a collection of keypads (transmitters or "clickers") for students and a dedicated software component. The software application is installed on the instructor's computer so that the teacher may use it to create interactive presentations. Since the students use their keypads instead of raising hands to submit answers, the individual responses stay confidential, i.e. the rest of the class is not aware of the individual's answers, while result overviews

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are still available on the classroom screen by way of visual technology. There are several commercial systems available on the market (Rize & Bunz 2006). They provide variations in functionality, and use infrared or radio frequencies to facilitate the methods for communication. Some systems are limited to multiple choice type questions, while other systems include yes or no, true or false, as well as text and numeric responses. In Europe the price of commercial SRSs constitutes one of the main factors that limit the penetration rate in education.

Higher educational institutions are today crowded with media competent students that have grown up with the ICT revolution, resulting in their digital skills helping to promote new ways of organizing and facilitating learning. At the same time modern society requires large-scale education. The consequence is a growing number of students in higher education that are more or less eroding the potential for teachers and learners to engage in meaningful dialogue in undergraduate study programs. Indeed, large-scale lectures seem to be the normal format of organizing learning in higher educational institutions, despite student demands and outspoken scepticism at the political level. Traditional lectures are effective for presenting information in large classes (Costin 1972; Bonwell & Eison 1991; Ekeler 1994; Jarvis 2002). The large enrolment courses are the bane of active learning according to Trees & Jackson (Trees 2007), though in this learning environment traditional lectures are most appropriate because they are the obvious strategy in order to reduce the educational costs per student. On the other hand, it is doubtful whether such large scale lecturing manages to move beyond surface learning, and promote the involvement, engagement, and active learning that we often want from students.

A question that arises is if it is possible to combine the use of modern ICT technology on widely available mobile devices with new pedagogical methods, and design interfaces that are intuitive to use in such a way that it is indeed possible to promote use of cheap, user-friendly and widely available mobile computing solutions that may merge into any teacher’s lecturing in any class for any kind of student group. Such mobile computing solutions should promote student-led interactive learning in order to help improve their learning results. The mobile computing solutions should be highly flexible and adaptable, keeping in mind that external conditions within an e-learning framework may change at short notice and require other ways of organizing learning that are more effective.

The European Commission is currently co-funding a project during the period 2009 – 2010 that within these pedagogical perspectives is developing and testing a brand new prototype of an open, web-based SRS for PC, iPod Touch, iPhone and mobile devices that can read HTML pages. This article presents the first results and experiences obtained during the fall 2009 in physics and engineering education, when using the new type of SRS for next generation wireless mobile handheld devices with pressure sensitive, high resolution screens.

Turning Point Technologies in the US has developed a clicker based response system (Turningpoint 2009) that may run on multiple platforms. The WI-FI based system for iPod Touch and Blackberry was available in 2009. University of Austin is currently developing a web based mobile course assessment system (Moca 2009) for collecting on demand student feedback using mobile devices like Blackberries, netbooks and iPod Touch. The system is compatible with a variety of computing platforms and devices. The system addressed in this article is compatible with a variety of computing platforms and devices. Although iPod Touch was chosen for testing of the SRS, our goal is to have a system independent of which mobile WI-FI device used. The SRS has been designed for fast and intuitive use, and to handle on-the-fly use without interrupting the teacher’s lecturing.

The development of the SRS for modern mobile devices has been done in close cooperation with a range of teachers, instructors, engineers, scientists, and students from higher education and vocational education and training schools in seven European countries. A learning centred approach, where implementing technology in learning is based on how learning in fact takes place and where the technology solves real educational problems, has led to this development. It has not been a matter of developing response services for mobile devices by using a “technology based approach”, as pointed out by Mayer (Mayer 2005), just because it represents progress or modernization in society. The key point is to avoid using technology that is not in alignment with how learning in fact does take place.

2. The challenge with large student groups

Sør-Trøndelag University College (HiST) is located in Trondheim, Norway. It currently supports 7000 students who are registered on undergraduate degree programmes. HiST provides one of the widest choices of subject areas in Norway, including eight separate programmes in engineering and technology disciplines. The bachelor courses are taught in a semester consisting of 15 weeks, giving 60 credit points per year. The class sizes are typically from 60 to 150 students, most of who are in the 19-22 age-group.

According to a recent evaluation of engineering education in Norway (NOKUT 2008), 45% of the engineering students complete their bachelor's degree within the stipulated time of three years. 60-70 of the students manage to get a final bachelor's degree by using additional time. It is in particular the basic courses like physics, statistics and mathematics, which turn out to be the critical courses. These courses are provided in the first and second year of the students' study. More than 50% of the engineering students are currently recruited from a pre-qualification course.

Currently at HiST 50% of the students that have been recruited from high school, and 70% of the students that have been recruited from the pre-qualification course, complete their bachelor's degree within the stipulated three years of study. This is better than the mean value in Norway. It is the ambition of HiST to provide an additional increase in the student flow rates in the bachelor education of engineers. This points to a large socioeconomic potential for HiST, as well as for education in Norway. However, the fact that such a large section of the student group has not obtained sufficient skills in mathematics and physics, presents additional challenges for the teachers and instructors. The large student groups, and the growth in student numbers, suggest that there is limited potential for dialogue and meaningful multi-way in-class dialogues and discussions. Indeed, during the last few years the teaching methods based on dialogue have been replaced with a less robust educationally didactic transmission of information, and mode of teaching in such a way that the cost per student has been reduced.

3. Wi-FI access network based student response technology

In Europe there are pockets of use of SRSs based upon commercial systems (Bates 2006, Hansen 2008, Draper & Brown 2004, Boyle & Nicol 2003) and they are growing. These institutions are to some extent early adopters trailing the technology in order to gain learning rewards. One of the main obstacles, however, turns out to be the costs per student in using such devices. Even though dedicated hardware based solutions including hand held "clickers" can be cheap to produce, commercial interests may in some countries results in cost of more than 100 Euros per hand-held unit per year. The appropriate software and signal receivers, as well as expensive support systems, add to these costs.

Existing SRS technology mostly supports multiple-choice questions. On the other hand, SRSs also let teachers sample extensive data about their students' knowledge in class. It is, for instance, hard to obtain such knowledge and gain an immediate overview of what the students know about a subject, by using traditional evaluation methods like oral examinations or written tests. Students and teachers have the advantage in using the SRS technology to go back and explain difficult matters once more or, in particular in large classes, to identify students who are lagging behind for extra attention by the teacher or by a teaching assistant. Furthermore, SRS is also a useful tool for using peer-assisted learning in large class settings. The systems can also be used for various assessment purposes.

It is possible today to buy mobile phones from Apple, Google, HTC, Nokia, Ericson, and Samsung with high-resolution touch screens. Many of them are still expensive, but prices are expected to go down, and within less than 2-3 years most students will actually buy modern mobile phones that are designed for IP communication through touch sensitive screens. Thus, it will be much cheaper to use a SRS dedicated to modern mobile phones as the institutions do not need to invest further in commercial and dedicated "clicker systems". The cost per device is going to be significantly reduced, by developing an SRS system dedicated to mobile computing solutions. Obviously, the threshold for using SRS technology will be significantly reduced as cheap solutions become available.

The development of mobile computing SRSs promotes another piece of technology to increase classroom interactivity. Interactive touch screen wallboards (e.g. Smartboard) are becoming more common in higher education classrooms and they seem to open up for new approaches to classroom communication. These devices open up for simultaneous production of instruction, distribution of appropriate learning material, and control of SRS on mobile devices, without destroying the teacher's lecturing. After lectures the written material that was produced by the teacher and the students through their interactive responses, can be posted on the institution's learning management system (e.g. Moodle, Blackboard or It's learning) and be made available for further study and reflection.

The instructor uses a new WI-FI based SRS through a dedicated control interface, which may be operated from a PC, a digital blackboard, an iPod or iPhone. This is achieved through easy and flexible integration with interactive touch screen blackboards by utilizing Flash in combination with Flex. The control interface provides session code registration in order to avoid interference between neighbouring classrooms. Students may use iPod Touch, iPhone, or any mobile device that can read HTML pages, to answer questions posed by the instructor. Questions can be as simple as yes/no/doesn't know, true/false/doesn't know, or multiple choice with 3 to 6 alternatives. Answers are tailed and can be instantly displayed after a polling. The system is web-based, whereby students that have access to Internet may be located anywhere. The control interface has been constructed for easy use on digital blackboard, keeping in mind that teachers may use any kind of software solutions during their lecture presentation. The SRS is currently being tested in vocational education and training, and in engineering courses, in Norway, the United Kingdom, Slovenia, Hungary, Slovakia, Sweden and Romania.

4. The active learning process

In recent years it seems that new digital media have virtually disseminated the culture of young adults. In a recent report from the MacArthur Foundation it has been pointed out that "Social network sites, online games, video-sharing sites and gadgets such as iPods and mobile phones are now fixtures of youth culture. They have so permeated young lives that it is hard to believe that less than a decade ago these technologies barely existed." (Hansen 2008). Availability of new media has accelerated over the last number of years, and we have seen an enormous increase in media use, both in terms of variation and in total quantity. New media seem to have changed the way young adults think, especially as the new generation is also highly media competent. Whereas in previous generations focus and concentration was the highway to learning, multitasking and simultaneous flow of information is the reality for the younger generation of today. Social availability and companionship the whole day via mobile phones and the Internet have in many instances replaced solitude.

The challenge for educational institutions seems to be how to utilize new media and mobile technology solutions that meet the demands of the young media competent generation, where creation of knowledge and understanding more or less is a continuous process that is constructed and reconstructed frequently due to rapid and new technological achievements. Using instructional technology simply to use technology in the classroom without any instructional purpose or linkage to modern-day use of technology does not improve the classroom experience for media competent students. Indeed, to rely on a traditional Cartesian view of knowledge creation where pieces of information are being transferred more or less one by one, is going to be challenging for many educational institutions. Learning in modern educational institutions is an interactive process-taking place within a community of students where many of the relations are mediated through media technologies like MSN, Skype, YouTube, Facebook, etc. Thus, mobile computing technology and its educational implementation need to take as their stepping stone the ICT tools that the students are already using. Use of activity-based training (Stav 2008) seems to be such a promising approach mixing pedagogy with use and inclusion of modern ICT solutions.

5. Educational use

Existing SRS systems based on clickers require that students receive a small hardware based device. For many educational institutions this become far too expensive, thereby limiting the utilization of new pedagogical methodologies based on anonymous feedback from students during training sessions. The new services (Stav 2009, Pein 2009) use the existing wireless network inside the institutions, thus the educational institutions' need to further invest in expensive equipment dedicated for voting sessions. The mobile computing based SRS system provides an economic or cost effective solution by utilizing widely available mobile, wireless multi touch pressure sensitive hand held devices, e.g. iPod Touch, iPhone or mobile devices, so that students may interact with the teacher through online questionnaires and voting systems. The teacher collects and visualizes the responses from class on the digital blackboard, by utilizing state of the art SRS decision process solutions. SRS mainly supports multiple-choice questions, but teachers can sample extensive data regarding their students' knowledge that is otherwise hard to obtain. SRS can identify students who are lagging behind for extra attention, and they are useful tools for scaffolding peer-assisted learning in large classes.

The teacher gives the students a task, for instance a question or a problem. The students solve the task and respond by using the SRS either on their laptop or through their mobile handheld device, e.g. iPhone, as displayed in prototype solutions in figure 1. The results are displayed anonymously on the digital blackboard, with the teacher getting a knowledge map of the class. Finally, the teacher must decide how he/she will proceed. The results show if the class is struggling with the current part of the curriculum, and he/she must decide the amount of time needed for that part based on the result. Thus, the SRS provides pedagogical methods that enhance interactive teaching models by using instructional feedback loops. The first test of a SRS for iPod and iPhone was done in a physics course for civil engineering students in the fall of 2009 in Trondheim. In the course of winter 2009-2010 it will be followed up with extensive testing (EduMecca 2008) in in-company training in mechanical industry in Norway, Slovenia, Slovakia, Hungary and Sweden as well as testing in several engineering classes in Trondheim.

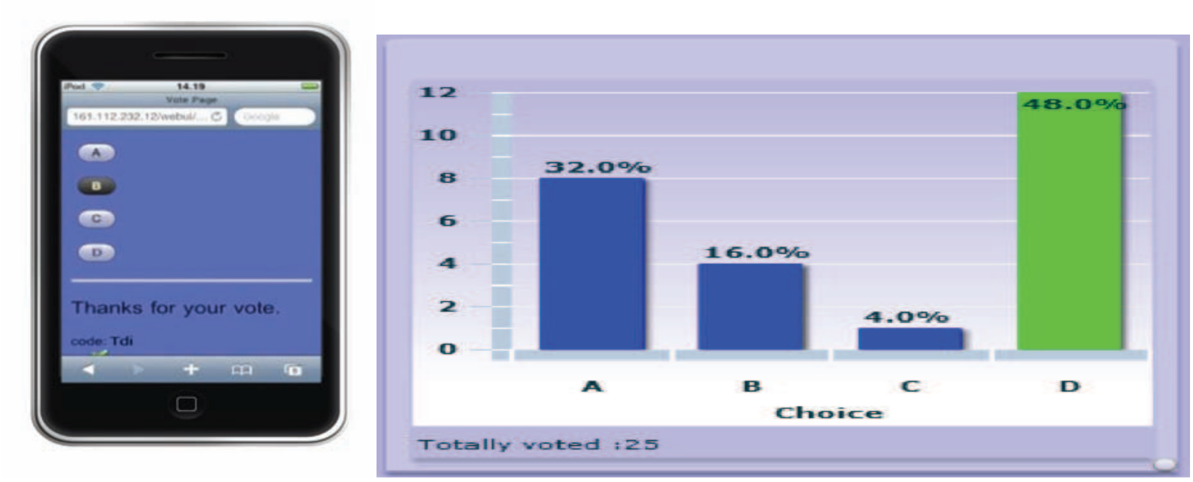

Figure 1: The students may respond by using an iPhone, iPod Touch or their mobile phone. The response is also displayed on the blackboard. The teacher can highlight the correct answer (green bar, right hand side)

6. Experiences obtained when using SRS in teaching of physics for civil engineering students

One of the main challenges with physics teaching at freshman level is that too many students have low mathematical and analytical skills. As a consequence, a physics course often consists of making the students memorize rather than understand the physical concepts. Students manage to solve the tasks as long as problems consist of similar, almost identical, situations. However, even small changes in the tasks, will make many students unable to even start solving the problem. One way of utilizing SRS in physics teaching is to test the students' physics understanding by asking conceptual multiple choice questions during the lectures, often in a learning environment where they can not rely on looking up examples from the textbook. Answering the questions must therefore depend purely on physical understanding (Mazur 1997). The students have to discuss and argue with their neighboring students and through peer discussion they also gain experience in explaining physics.

A typical SRS mobile device session has the following structure:

- Handheld units (iPods) are distributed before class begins
- Teacher starts the SRS for mobile devices when he/she is ready to teach, and the students enter the session code just before the lecturing starts. The session codes allocate the class to one lecture room, whereby several neighbouring classrooms may use the same WI-FI network in parallel.
- Teacher presents new material from the curriculum
- Students are presented with a conceptual quiz and asked to discuss with each other for 2-3 minutes

- The teacher starts a voting session by using a web interface on the digital blackboard
- Student casts individual votes using the handheld units.
- The vote is closed and results are presented on the blackboard (immediately or when the teacher decides)
- The teacher comments on the various alternatives and highlights the correct one, explaining thoroughly why it is the correct one and why the others are incorrect.
- The teacher goes back to point 3 and repeats.

A lesson consists of 2 lectures, each lasting about 45 minutes. During each 45 minutes period the students are usually presented with a maximum of 2 conceptual questions. In order to start a polling session (which usually lasts 30 seconds), a "ticking clock" is used to shift the students' attention away from discussion and over to the voting session in progress. The first testing of SRS for mobile devices was done over a period of 5 weeks. Students' feedbacks on the system were collected from a survey given at the end of the test period. A selection of the results obtained from 59 students (45 male and 14 female) is displayed in table 1. These results together with inteviews with students show a clear positive picture on using the SRS during class. Students agree that the SRS encourages the students to be active during the lecture, and they feel that using SRS helps them to learn the syllabus topics.

Table 1: Responses obtained in a survey from the first physics course that used the SRS, the numbers represent number of students selecting that alternative. The upper numbers represent the male answers while the lower numbers represent female answers

No.	Survey question/statement	Very good	Good	Ok	Fairly good	Poor
1.	My first impression of the SRS is	7 7	29 4	6 1	2 1	1 1
2.	I think the manner in which the lectures using SRS have worked is	13 6	24 5	7 1	0 1	1 1
		Very large	Large	Neutral	Small	Poor
3.	To what extent does the SRS encourage and activate the students?	20 6	20 6	3 1	1 0	1 1
4.	How would you assess the value of the group discussion before voting?	21 6	16 5	3 2	3 0	2 1
5.	To what extent does the SRS aid your learning of the course curriculum?	7 3	28 5	5 4	4 0	1 2
6.	To what extent does the teacher's explanation at the end of the vote aid your learning?	30 10	11 3	2 1	0 0	1 0
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
7.	It's fun to be at lectures where SRS is used	7 7	26 4	9 2	2 0	1 1
8.	Through the use of SRS, I can give the teacher a response to his/her teaching approach, and thereby influence the learning process	6 3	22 3	11 6	5 1	0 1
9.	SRS should be used in all classes/lectures	15 8	19 4	6 0	3 1	2 1
10.	The SRS gives me an opportunity to actively take part during the lecture.	5 2	24 8	13 2	3 0	0 2
11.	Using SRS during a lecture makes me an active as opposed to passive, student.	3 0	15 6	22 4	4 2	1 2
12	The use of SRS compromises the ordinary lecture time	6 2	8 2	5 3	17 1	9 6

The new SRS system for hand held mobile devices has been developed for the web, and all communication is solved via communication through HTTP, from web pages to web services, both from student perspectives and teacher perspectives. The SRS control interface solves several flow problems that the web control interface introduces in the classroom.

- The web based control interface is a web page. For the teacher to start, control and present results, he/she must have a web browser in addition to other software in the classroom.
- The applications will cover the lecture material that the teacher has, and it is difficult to show results together with the questions.

The teachers report that the control interface application is simple to use, and the interface may be used together with any presentation software. Furthermore, they appreciate that:

- The access code is always easily available for students.
- It is possible to present the results together with the question and the alternatives.
- It is easy to hide the software when the teacher so wishes.

The teachers report that they just need a few minutes to learn to operate the SRS due to the intuitive design of the control interfaces.

The research results will be used to propose and disseminate a new method for organizing and delivering undergraduate engineering courses, as well as in-company training solutions. Furthermore, it is expected that our results will lead to increased student flow rates in undergraduate engineering programs, addressing the macroeconomic potential, through attractive and popular learning rewards.

7. Experiences obtained when using SRS in distance teaching

Using an SRS based on wireless Internet connection has many benefits as opposed to the traditional clickers using for instance infrared sensors. Apart from cost, using WI-FI does not restrict the users to being in the vicinity of the instructor. An SRS developed for internet connection may be used for distance teaching purposes. Figure 2 and 3 illustrate how the SRS has been used in an instructor training course in Visonta, Hungary. The teacher is providing the course by using digital blackboards and two-way video from Trondheim, Norway. The first use of SRS in distance teaching was on 29th of January 2009. The distance from Trondheim to Visonta is 2291 km.

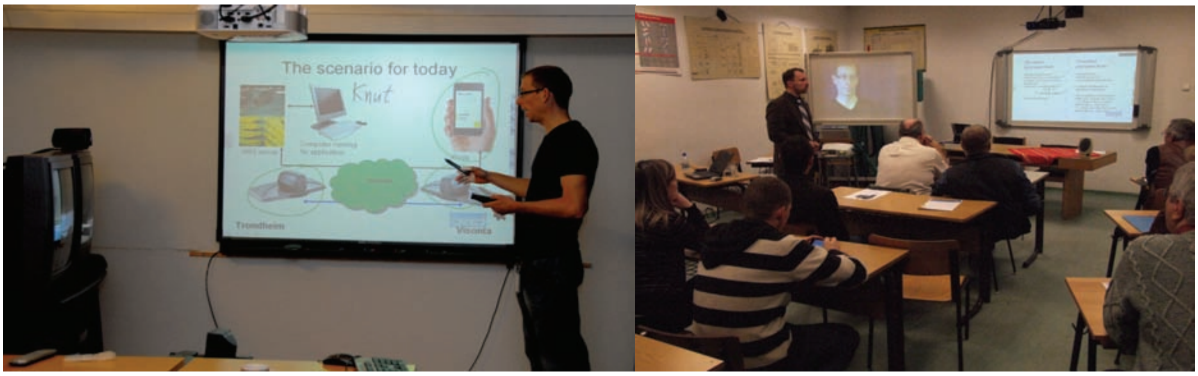

Figure 2: The first use of SRS in distance teaching was in January 2009, the teacher (left picture) is lecturing from Trondheim, Norway. The students that receive the training (right picture) are located in Visonta, Hungary the teacher and participants communicate two-way by use of video conferencing

The picture on the left hand side in figure 2 shows that a camera on the top of the monitor records the instructor. This picture is transferred to the large screen on the left hand side in Visonta. The instructor uses a Smartboard to demonstrate and operate the SRS. The picture of the Smartboard is transferred as a parallel video signal and is transferred to the projection surface on the right hand side in Visonta. The students have a camera and a microphone in front of them, and this picture of the class is transferred back to the instructor on one of his monitors. Thus, by doing it in this manner real two-way communication is obtained as the students may always observe the instructor and at the same time his presentation. They may also at any time ask the instructors questions, thus achieving real two-way communication experience since the instructor may watch his students on the screen in front of him. In addition to the video communication, we run the SRS communication in parallel. The students' iPods are interconnected to a server, which are located in Trondheim. The computer running the SRS application is connected to the same server, and the computer screen is displayed on the Smartboard.

E-learning courses may be provided at different levels, ranging from pure e-learning solutions where the student only uses the computer, to a system where the students use the computer and on demand or streaming video resources, and high level courses that combine e-learning, video streaming and two-way multipoint videoconferencing solutions that may transfer two parallel video streams (the teacher and the presentation) by use of for instance digital blackboards. The latter system solution is usually done in blended learning. Figure 3 demonstrates a one-to-one videoconferencing-based training solution; the picture of the Smartboard is transferred through one channel, while the other channel always tracks the instructor. The SRS may easily be integrated into such a training framework, if the students at the far end site may access a wireless network with their mobile devices. The teacher may operate the SRS from the digital blackboard, and start the polling. The students respond by using their devices, and the answer is displayed on the digital blackboard and immediately transferred to the far end site. By using the SRS in this way, it is easy to promote interactive discussions within the student group both before and after a polling session.

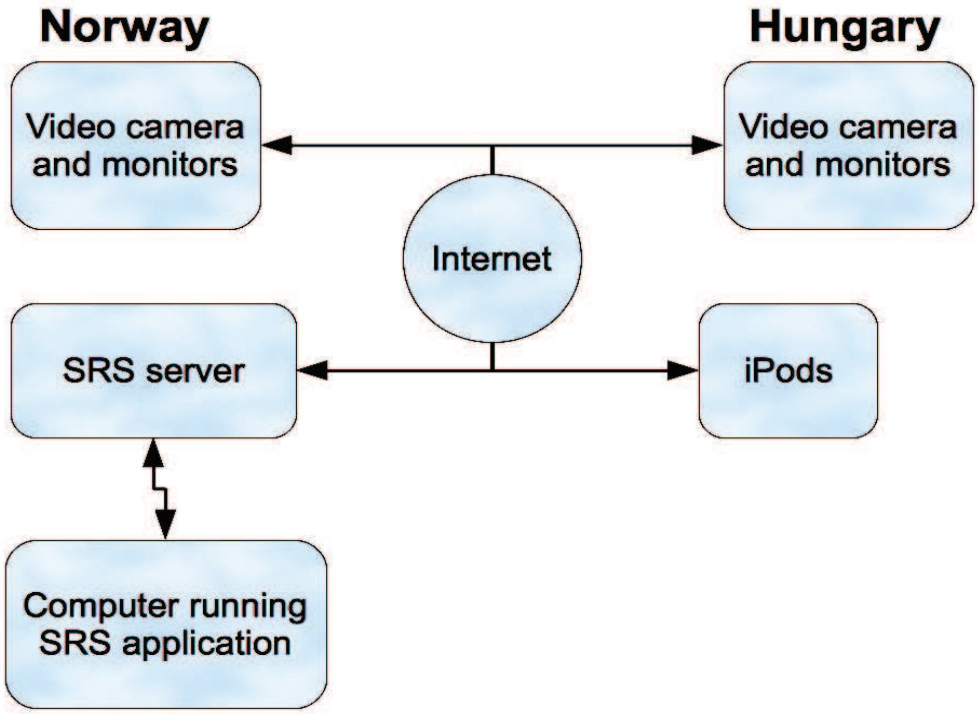

Figure 3: A schematic outline of the video and SRS IP based communication infrastructure during an instruction-training course from Trondheim, Norway, to Visonta, Hungary the teacher (in Norway) and participants communicate two-way by use of video conferencing. The teacher is running the SRS application on a digital blackboard and the participants can see the display on their monitors

The system solution shown here is easy to use and fast to install if mobile video devices are used. Our experiences show that this system's solution yields the student very good quality of the audio as well as the video pictures. A regional video network is for instance being constructed and implemented in central and western parts of Romania (Move-IT 2009, Stav 2010) by using equivalent principles for obtaining two-way video communication. The network utilizes high definition video solutions to improve the inter-institutional partnership between existing vocational training centres and the regional University Petrus Maior in the central part of Romania. The vocational schools are located in the towns of Oradea (University Agora), Alba Iulia (Universitatea 1 Decembrie 1918) and Sighisoara (Colegiul National Mircea Eliade). The distances from the hub (University Petrus Maior) and to the sites are from 60 - 225 km. Transfer of best practices and knowledge from state of the art use of video in education in Norway is included in this construction of the network. The teaching infrastructure is being renovated in order to improve working conditions for providers of vocational education, and improve vocational training quality by making it more adaptable to the Romanian labour market. The validation of the infrastructure will be done by delivering a number of vocational education and training courses. A range of courses is foreseen, for instance Quality Management, Health and Safety Management, Environmental Management, and Economical Engineering. The participating training organizations and industrial companies in Romania may use the new training environment to offer and receive a broad range of specialized courses, including transnational exchange of competence transfer. The SRS is also during the period 2009 to 2011 going to be adapted, implemented and used to provide improved training solutions within industrial oriented quality assurance training processes in several countries in Europe (DO-IT 2009). It is a trans-European consortium that has initiated this Leonardo project. The ambitions are to combine use of SRS with case based training in order to make the training relevant and targeted.

8. Design of SRS for mobile computing solutions

It is recommended (Pascal 2009) to use a design that follows the REST style, whereby widely used communication protocols like the Hypertext Transfer Protocol (HTTP) are obvious. In doing so, all required learning resources can be made accessible as Uniform Resource Locators (URL), with the services being virtually accessible anywhere in the World Wide Web. It is for instance not necessary to have an Apple account in order to download any software or services through iTunes Store. In this way any iPod Touch or iPhone may run and use the services through a Wi-FI network. The iPhone may also use the 3G or Edge network, but then it will result in some additional costs due to the fees on the mobile network. Using Extensible Markup Language (XML) in combination with Extensible Stylesheet Language Transformations (XSLT) achieves high portability, as well as allowing external services to process data easily. The teacher starts the voting session when the lesson starts, and the SRS automatically generates a session code to be used by the students. They log into the session by entering this number once when the lessons starts, with every student from a practical point of view providing anonymous answers.

In order to visualize learning material, questionnaires, figures and information, the best format needs to be chosen. The limited size of the windows of the iPod, iPhone and other mobile phones is challenging. Texts are usually displayable directly on most devices, either unformatted or formatted. It is, however, challenging to display long sentences, as it will require that the student scroll down the window. Forthcoming research analysis decides which capabilities of the client device that will be used. Questionnaires (text and figures) may be converted into formats such as Hyper Text Markup Language (HTML), Extensible Hypertext Markup Language (XHTML), Portable Document Format (PDF) or Wireless Markup Language (WML). Further SRS design considerations are given in Pascal 2009.

9. Discussion and conclusion

The prototype solution for a new type of Student Response Services (SRS) for next generation mobile handheld devices with pressure sensitive screens, e.g. like iPOD Touch and iPhone, has been demonstrated. The SRS provides user interfaces that are intuitive to use. This includes session control, a flexible framework for generating questionnaires on-the-fly, easy to use interfaces for controlling the voting session by the teachers, and easy to use interfaces for voting on mobile devices by the students. The WI-FI based SRS has been designed such that it helps the instructor or teacher to:

- Break the monotony of a lecture and allow the students to actively take part in the lecture
- Increase teacher-student interaction
- Give both teacher and students "real-time" feedback on learning effect
- Use modern, cheap and widely available devices which students soon have access to through their mobile phones
- Use devices that start fast (within 2-3 seconds) in order to merge their use into the lecturing.

The pilot testing has used an instructor-led educational process that contained the following elements:

- Short sequential lessons, followed up by tasks where students give feedback by using SRS
- SRS questionnaires that exploit ICT enhanced learning assets
- Structured, critical thinking and creative problem based learning activities that collect individual responses anonymously

- A flexible in-class discussion sequence, that in some cases may end up with a new SRS decision process
- Summary and explanation, reflecting the profile of the response from class
- The system solution is web based and generic, thus enhancing its utilization in all kinds of process and product oriented instruction and training activities.

The students provide positive feedback with respect to increased engagement and motivation, which is in accordance with results reported in the literature by use of traditional clicker based systems (Dangel & Wang 2008). Many students feel it becomes fun to attend the lectures. They also point out that the SRS has become an integrated part of the teaching practices, since it is intuitive, easy and fast to operate by the teachers and by the students themselves. The services are constructed for easy integration and use on digital blackboards, as well as smooth integration into the lecturing provided by the teacher. The students may use widely available mobile, wireless multi touch pressure sensitive hand held devices, or a PC/laptop, to interact anonymously with the teacher through online questionnaires and voting sessions. The SRS prototype services were available in the fall of 2009. The new services extend and replace existing voting systems where universities and vocational educational training institutions had to buy dedicated and expensive hardware tools, so-called "clickers" or electronic voting systems, in order to provide feedback from students during training sessions. The development of the new SRS services will be completed at the end of 2010.

The services are based upon XML-based standards and web authoring facilities for the contents available on web pages, by providing XML-based universal notation and interface including visualization of scientific and engineering drawings and graphs. The search facilities retrieve the postulates of the instructor through a service-oriented architecture that integrates semantic web into the system for retrieval of information from the knowledge base system. The SRS decision process solution system is open and flexible in order to achieve maximum interoperability. Pedagogical challenges related to the new roles of the teacher and the students in the educational process have been demonstrated. Experiences from the first testing period of the SRS system have provided valuable information targeting challenges, as well as “best practices” for using such systems in large classrooms. The system must be intuitive and easy to use, both for students and the teachers. It should not be an additional service that is compromising the lecture by spending valuable lecture time.

It is recommended to use a lecture room that has been prepared for use of digital teaching methods. This includes sufficient capacity in the WI-FI network and proper locations of projectors. The interface of the SRS has been designed to be as time efficient as possible. This has been achieved by obtaining continual feedback from students and teachers during the design period, and by carrying out extensive observations during class lectures. This evaluation framework has been used to improve the interface of the SRS for mobile devices.

The SRS has been designed for use in any kind of class, including services that help the instructor to maintain order and discipline in large classes. After the group discussion, the teacher usually wants to start the polling session. However, our experiences show that it is very challenging to restore order and attention in a large class of students that has been engaged in serious discussion. In particular, in order to make all the students, some still fiercely involved in the discussion, aware that a polling session is going to start up, it is necessary to use a “ticking clock”. This is a very efficient way of gaining the students’ attention. The results obtained in the evaluation survey show that the peer discussions between students are invaluable to the students’ perception of and benefits from using SRS. The teacher must be very specific and clearly tell the students when they shall start up the discussion phase, just after the task has been displayed for the student group. If the teacher does not do that, there is a risk that an SRS polling session steals too much lecturing time.

The survey in table 1 shows a general agreement between the male and female students on the receptions of the system, and most students are very positive towards using SRS in their course. Most of the students are satisfied with the use of the SRS, as shown in question no. 1 and 2. The responses to questions no. 4-6 show that the students believe the learning effect obtained by using SRS is achieved during the communication process before (teacher explains the question), during (students discuss), and after the polling session when the teacher explains why the correct alternative is correct, as well as why the wrong alternatives are not correct. Indeed, question no. 7 shows that if these 3 conditions are achieved, it becomes fun for most of the students to attend lectures where

SRS is used. A majority of the students want to use the SRS in all lectures, as shown in response to question no. 9. Notice, however, that the students expect very time efficient usage of the SRS, as displayed in question no. 12. During the first testing period we had technical problems related to a reduced capacity in the access network, as well as the technical infrastructure in the classroom. As a consequence of this, it took too long a time to run a polling session, resulting in the usage not being a natural part of the lecturing. Furthermore, question no. 8 indicates that the male students have a slightly higher tendency (than the female students) to feel that SRS stimulates them to give the teacher responses. A reason for this may be that the female students were a minority group. Further testing is required to check if there are significant differences in genders when it comes to the experience of using student response systems.

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