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Integrating a Lightweight Mobile Quiz on Mobile Devices into the Existing University Infrastructure

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Abstract: In this paper, we evaluate an approach of a lightweight quiz application for mobile devices. The idea is to use the students' own smartphones as voting devices and provide a quiz administration module, which is integrated into the existing university's e-learning platform. For establishing the link between the devices and the system we use dynamically generated Quick Response (QR) Codes. We briefly evaluate the approach regarding usability for students and lecturers, limits of the QR code, and the impact on the university's network infrastructure.

Introduction

Electronic voting systems (often called TED systems) are an interesting concept of modern e-learning for schools and universities (Scheele, 2005). They allow the lecturer to get quick feedback about the state of knowledge, comprehension, and opinions of the listeners. Students can express their knowledge without stepping forward in front of the entire auditorium.

However, some drawbacks of traditional voting systems have to be considered: The voting devices and the corresponding receiver are expensive, and the wireless devices have to be distributed to the students before the start of every lecture. The acquisition costs, the administrative overhead, and the risk of loss of devices increases with larger numbers of students. The content of the quiz has to be prepared before the lecture starts, and the answering options are severely limited by the design of the devices (e.g., textual multiple-choice questions only).

At the University of Mannheim, we have developed a lightweight system, which enables lecturers to ask ad-hoc questions to all students in a very quick and spontaneous way. One goal of our system is that whenever a lecturer comes up with an interesting question, it should be possible to create an ad hoc quiz within a few minutes. The system should be easy to use by both lecturers and students.

Our idea is to exploit the proliferation of smartphones and laptops among students and to implement a *Mobile Quiz Application* as an extension of our existing e-learning management system ILIAS. Nowadays, most students own a smartphone or another mobile Web-enabled device like a netbook, a laptop, or a tablet. All these devices have built-in wireless LAN access and thus have the ability to be used as voting devices. Many courses at our university use e-learning groups in ILIAS. Therefore, we have implemented a plugin for ILIAS, which allows the lecturers to create, maintain and perform ad-hoc quizzes during a lecture without the need of an additional system. The quiz itself is visualized as a Web app on the students' devices and needs no preparation or installation. With the start of a quiz round, a QR code (ISO, 2006) and a link in plain text are shown on the projection screen. The students can participate in the quiz by scanning the code with a barcode reader, or manually enter the link in a web browser. After the quiz is finished, the aggregated results are displayed on the projection screen and the lecturer can discuss them with the students. Figure 1 gives a brief overview of the process of our *Quiz Tool*.

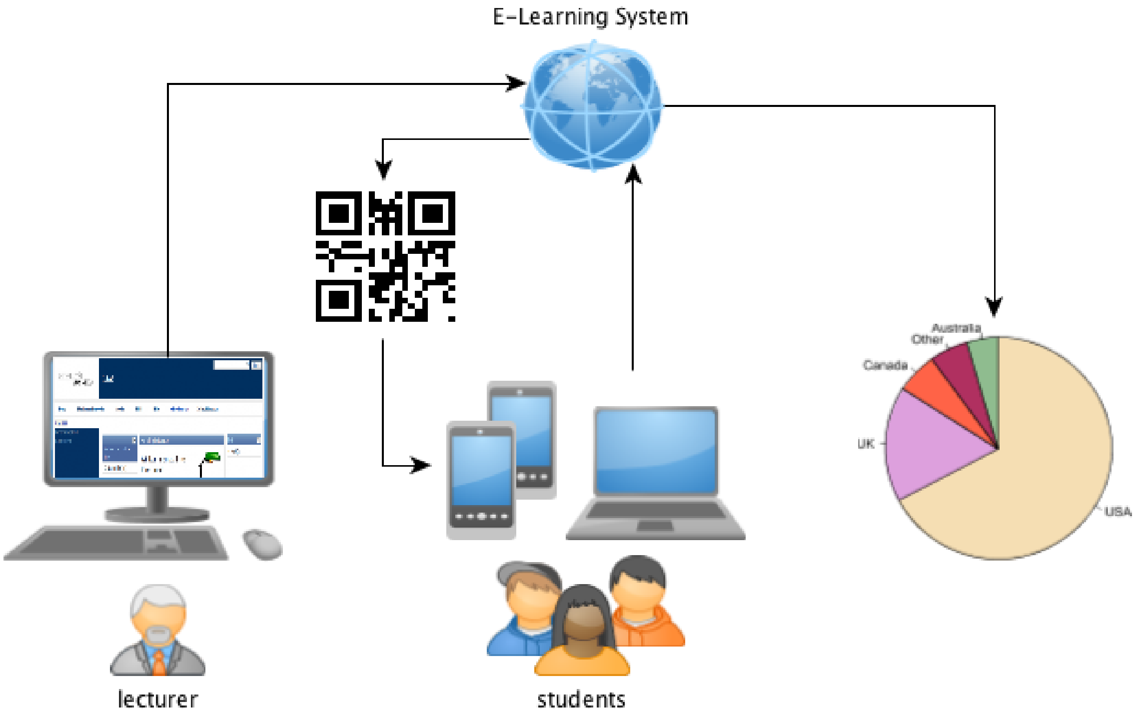

Figure 1: Overview of the Quiz Software

In the following, we describe the related work, give an overview of the implemented architecture, present first evaluation results of user acceptance and technical impact, discuss our results, and point out further work.

Related Work

From the point of view of educational psychology, learning should be an active process (Honebein, 1996; Wilson, 1991). Interactivity is highly relevant for the individual learning success and gives the learner the opportunity to actively shape the learning process, rather than remaining a passive recipient. Thus, an active involvement of the learners has a great impact on the success of learning activities (Ramsden, 1992).

The aim of early systems like *Classtalk* (Dufresne, 1996) is to improve the involvement of every single student. Therefore, the teacher transfers three to four *Classtalk* tasks per lesson to the students' devices which were calculators, organizers, or PCs at that time. Another early approach is the *ConcertStudeo* project which uses an electronic blackboard combined with handheld devices (Dawabi, 2003). It offers exercises and interactions such as multiple-choice quizzes, brainstorming sessions, or queries. The Classroom Feedback System (CFS) is designed for online feedback (Anderson, 2003) and allows students to post annotations directly on lecture slides.

Scheele and Kopf have developed the Wireless Interactive Learning (WIL/MA) system to support interactive lectures (Scheele, 2005; Kopf, 2007). It consists of a server and a client software part; the latter runs on handheld mobile devices. Both components communicate using a Wi-Fi network specifically set up for this purpose. The software consists of a quiz, a chat, a feedback, and a call-in module and is designed to be easily extendable. The main problem is that students need to have a JAVA compatible handheld device, and they need to install the client software.

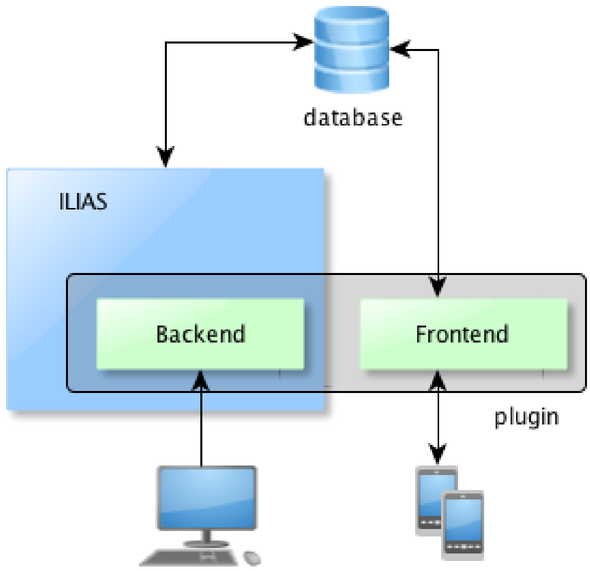

Figure 2: System architecture

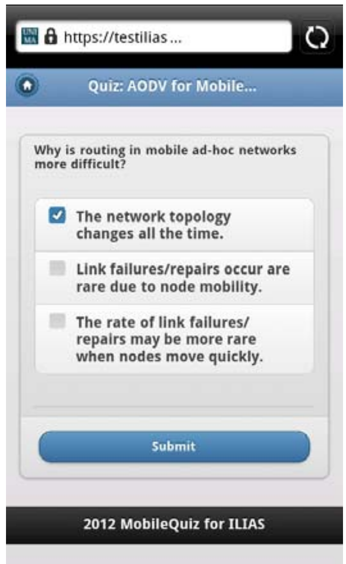

Figure 3: Screenshot of the Mobile Quiz Application

Ijtihadie et al. (Ijtihadie, 2010) propose to use an offline Moodle learning management system. The system is implemented with HTML 5 that supports offline application capability. Mehta et al. (Mehta, 2010) have developed a JAVA based simulation tool that is connected to a learning management system that supports quizzes, online labs, animated demos, and video lectures. Tabata et al. (Tabata, 2010) present an online learning tool for the iPhone that allows students to answer quizzes at any time.

We define three requirements for our *Mobile Quiz Application*: (1) No additional software should have to be installed on the mobile device. (2) Almost all modern mobile devices should be supported. (3) The system should be integrated into the learning management system. None of the existing systems considers all three requirements. In our opinion, it is much more suitable to require only a web browser and of course, every smartphone, notebook, or tablet has one. In addition, in recent years, learning management systems (LMS) have become commonplace in universities, and thus an integration of the quiz tool into the LMS is reasonable.

System Overview

Our *Mobile Quiz Application* consists of two parts: a backend providing the view for the lecturer and a frontend for the quiz participants. Both access data from the same database but are technically independent. This makes it easy to replace these modules at a future point in time. The backend is implemented as a plugin for the university's e-learning platform ILIAS, as shown in Figure 2. Although the frontend is independent from ILAS, it is delivered in the same software package, which simplifies the installation and maintenance of the system.

The Backend System

ILIAS stands for 'Integrated Learning, Information, and Work Cooperation System' and is an open source e-learning software published under the terms of the GNU General Public License. It is written in PHP, and it is maintained and extended by an increasing number of participants.

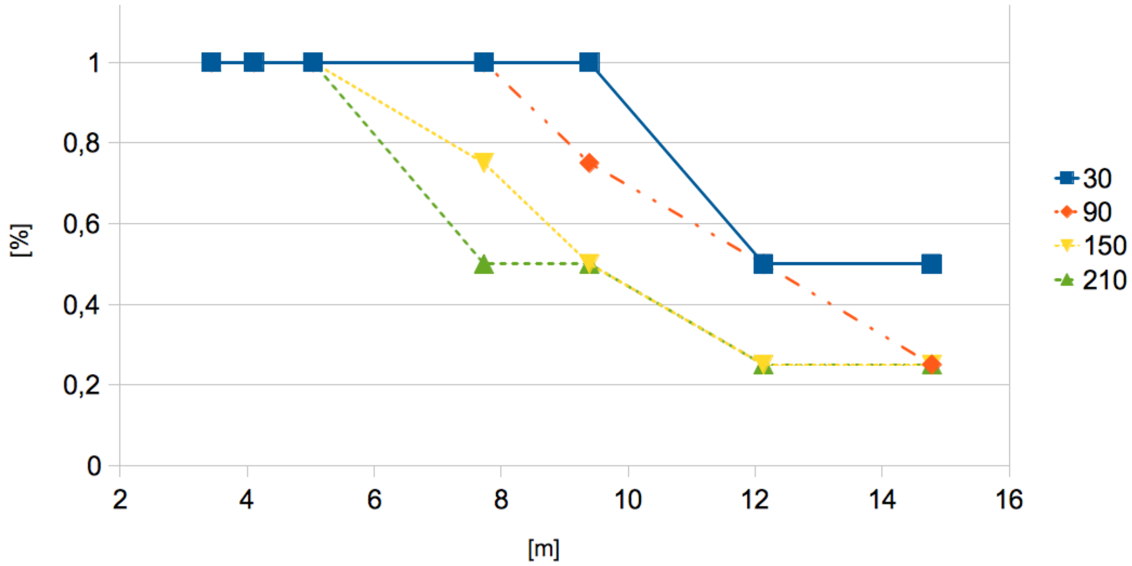

Figure 4: Readability of QR codes with 30, 90, 150 and 210 characters in different distances

One of its components is a comprehensive survey tool, which supports many different question types. Unfortunately, it does not meet our needs very well because it is not designed to create quizzes spontaneously, e.g., within a lecture. Furthermore, it does not allow anonymous quizzes, and it is not designed to support mobile devices. However, being a productive system, it already provides rights and roles management, and most lecturers are familiar with it. We thus decided to develop a plugin for ILIAS as part of the backend system. All the management activities, like creating questions, starting quiz rounds and visualizing the results can be done within ILIAS.

Quick Response Codes

To simplify the process of getting access to the quizzes we use Quick Response Codes (QR codes) to display links to those quizzes as machine-readable images. Students can use their phone's camera and standard QR software to access a quiz without the need of manually typing a link using the tiny keyboards of their mobile phones. QR codes are two-dimensional barcodes, which store the data in a square pattern of black modules on a white background. Although this technology can be used to encode any kind of data, it is especially useful to represent links to web pages. QR codes are often found in advertisements, linking to further information about the event or product. There are several standards, including ISO/IEC18004 (ISO/IEC, 2006) for the physical encoding and a de facto standard for encoding URLs from NTT DoCoMo. The latter is optimized for fast readability, and it includes error correction to enhance its robustness. Because the error correction is designed for burst errors, which are unlikely to occur when displaying the code on a screen, we used the minimum allowable amount of error correction for creating the QR codes.

The Frontend System

One of our main goals is to make the *Mobile Quiz Application* compatible with as many devices as possible. It should be easy for students to answer the questions. Furthermore, the application has to be robust regarding connection drops. We decided to implement our quiz as a web application by using existing web technologies based on the jQuery mobile web framework. The main advantage is the high accessibility rate for a wide range of small mobile devices as well as laptops, netbooks and tablets.

Evaluation

Although our system is designed for good usability and easy accessibility, we were confronted with several difficulties. The bandwidth requirements for the Wi-Fi network, the students' acceptance, and the technical implementation of the QR code were the biggest challenges.

Evaluating the QR Code

We did some experiments to evaluate the limits of the QR code technology. We measured the readability of these codes in different sizes and with different error correction levels, using the four different mobile devices shown in Table 1. The tests were done in one of our lecture rooms (with 140 seats) in normal daylight conditions. When increasing the number of encoded characters or the level of error correction, the amount of black and white squares within the code increases and the size of them shrinks. This impairs the

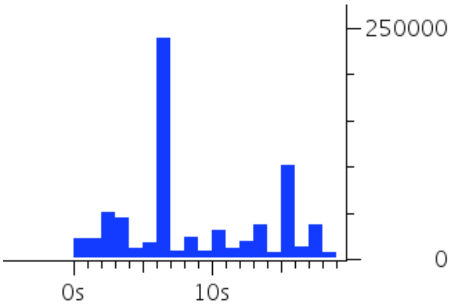

Figure 5: Network load in bits/s when using the quiz

readability. Our experiments showed that using a minimal level of error correction resulted in the best readability. The reason for this is due to the used method of error correction. It is designed for burst errors, e.g. losing a corner of the code. However, these kind of errors are unlikely to occur when displaying the QR code on a projection screen. Figure 4 shows the impact of the number of encoded characters on the readability. The two devices with an 8 megapixel camera were able to read the 30 letter code from every position in the classroom whereas the two 5-megapixel cameras failed at a distance of about twelve meters. Only one device was able to read all codes from every distance. Consequently, we decided to use QR codes with minimal redundancy.

Table 1: Test devices and their camera resolution

Device	HTC Hero	HTC Desire HD	IPhone 4	Samsung Galaxy S2
Resolution	5 megapixel	8 megapixel	5 megapixel	8 megapixel

Load on University Infrastructure

Besides the readability of the QR codes, we identified difficulties that were not that easy to solve. Because we wanted to avoid setting up a dedicated network, all devices had to use the existing university Wi-Fi network or the data network of their mobile network provider. Unfortunately, the Wi-Fi network at our university is not designed to serve more than a hundred parallel data connections in one room. Therefore, we were interested in the network load and delay, which is caused by using our quiz.

Figure 6: Example of QR code in Course

Figure 7: Discussing the Answers in Course

Figure 5 shows a capture of network load for one quiz participant. In this case, a quiz with five questions and three possible answers is used. The download to the device causes about 240 Kbits. The upload for submitting the answers causes about 100 Kbits of traffic load. Altogether, 340 Kbits of network load arises for each participant. The largest part of the downloaded data consists of pictures, which were used for the layout and the jQuery-libraries.

Beside the data capture for one participant, we also measured the load directly within the Wi-Fi access points of our university. We tested the quiz in one of our real lectures and looked at the load on all nearby access points for the whole lecture time. The students were asked to bring a Web-enabled device and to participate in two quiz rounds. Unfortunately, because of the upcoming Easter break, the course was poorly attended with only nine students. Seven students participated in at least one quiz round. Except one student who used the data connection of his mobile network provider, all connected to the quiz via the university's Wi-Fi network. The additional network traffic of the six devices, which participated in the quiz round, could not be recognized in the overall Wi-Fi traffic and was absorbed by general traffic noise. Our Wi-Fi access points can handle up to 100 Mbps, so even for more than 100 students the pure data load is no limitation.

Unfortunately, the Wi-Fi network delay increases with an increasing number of clients (see Xiao, 2004). Additional packets are needed to regulate the network traffic and to avoid packet collisions. This causes a noticeable packet overhead and increases the overall delay. Considering the small number of students in our testing scenario we did not notice an impact on network delay.

User Evaluation

In addition to the sole technical impact, we also evaluated the students' acceptance of the system. Those students, who had no smartphone with a QR code reader used their regular phones or laptops and entered the link to the quiz manually. The remaining two stated, that they could not participate in the quiz because they did not bring their device with them or their battery level was too low. These results support the statements of our lecturers who say that almost all students own a Web-enabled –and thus quiz-suitable– device.

Six students answered that the usage was fluid and uncomplicated. Only one of them, who manually typed in the link by using an old Sony Ericsson phone, had the impression that the usage is rather complicated and slow. None of the students had an objection against the quiz and four of them would like to see the quiz more regularly in their lectures.

We can confirm positive effects on students' motivation and learning success, which were already analyzed by Scheele et al. (Scheele 2005). Although the authors used different types of devices and technology, the pedagogical impact should be quite the same.

So far, we did not quantitatively evaluate the acceptance of the mobile quiz from the lecturers' point of view. But the first feedback we got was very positive. The integration into the existing university's e-learning system – which most of the lecturers use – simplifies the administration of the quiz rounds, insofar no new application software has to be learned. Using the students' devices reduces preparation and post processing time, which would be necessary for distributing and recollecting the voting devices. Because of this minimal preparation effort, spontaneous quiz rounds are made possible.

We are planning extended tests of our quiz application in the upcoming fall semester with several hundred students participating a single lecture. We are especially interested in the impact on the university network and the acceptance of the system by students and lecturers.

Conclusions and Outlook

In this paper, we introduced an innovative *Mobile Quiz Application*. We have designed and implemented an electronic quiz system, which can be administered via the university's e-learning platform and uses all forms of student-owned Web-enabled devices for voting. From our experiences, almost 100% of the students own at least one of these devices and thus are able to participate in the quiz rounds. We implemented the initial connection to the quiz with a QR code and evaluated its readability in a typical lecture room. We further evaluated the impact on the university's Wi-Fi infrastructure and the user acceptance. Lecturers and students of our university show keen interest in the system, and they are looking forward to a full rollout.

For future work, we are planning to do more experiments in larger lessons, investigate the impact on the wireless network in more detail, and extend the usability with more types of questions. We also plan to evaluate the effect on the learning outcome. In addition, we want to extend the *Mobile Quiz Application* by implementing further features like an offline mode, where the QR code is printed into the lecture notes, so that the students can participate to the quiz from home and get their individual result.

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