

MobileQuiz – A Lecture Survey Tool using Smartphones and QR Tags

Daniel Schön, Melanie Klinger, Stephan Kopf, Wolfgang Effelsberg

University of Mannheim

Mannheim, Germany

{schoen | Kopf | effelsberg } @informatik.uni-mannheim.de

klinger@ssl.uni-mannheim.de

ABSTRACT

In this paper, we present first experiences with the use of a lightweight, media-supporting quiz application for mobile devices. The idea is to use the students' own smartphones and laptops 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 platform we use dynamically generated Quick Response (QR) codes. The quiz is implemented as a web application, also providing the use of media content such as pictures and videos. We evaluate our approach with respect to usability, limitations of the mobile browser technology, the QR code, and the impact on the university's network infrastructure. Furthermore, we discuss the usefulness and usability of the quiz tool on the base of students' evaluations and our experiences while working with the lecturers.

Keywords

Mobile learning, e-learning, smartphone, survey, quiz, student feedback

1 INTRODUCTION

Electronic voting systems (often called TED systems) are an interesting concept of e-learning for schools and universities [1]. They allow the lecturer to get quick feedback about the state of knowledge, comprehension, and opinions of the listeners. Students can express their knowledge or opinion 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 a quiz can be started. 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 our university, we have developed a lightweight system that enables lecturers to ask ad-hoc questions electronically to all students in a very quick and spontaneous way. It is possible for the teacher to use multiple choice questions, questions requiring numeric answers and questions based on multimedia content such as pictures and videos. The system is easy to use by both lecturers and students.

Our idea is to exploit the proliferation of smartphones and laptops among students and to implement the *Mobile Quiz Application* as an extension of our already existing e-learning management system ILIAS [2].

Most students own a smartphone or another mobile web-enabled device like a netbook, a laptop, or a tablet. These devices have built-in Wi-Fi access and a Web browser, and thus have the ability to be used as voting devices. Most courses at our university use e-learning

groups in ILIAS. Therefore, we have implemented a plugin for ILIAS, allowing the lecturers to create, maintain, and perform prepared and ad-hoc quizzes during a lecture without the need of extra hardware. The quiz itself appears as a Web application on the students' devices and needs no additional software installation or platform login. With the start of a quiz round, a QR code [3] and a link in plain text are shown on the projection screen in front of the students. The students can participate in the quiz by scanning the code with a barcode reader, or they can manually enter the link into their 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.

In the following, we describe related work in the field of educational psychology as well as technical developments and then give an overview of our system architecture and the system itself. Subsequently, we present and discuss the results of an extensive evaluation concerning technical aspects (readability of QR code, load on the university infrastructure, browser technology) as well as usability, reliability and users' acceptance. Finally, we give an experience-based insight in the capabilities and challenges of the system and end with recommendations for further development.

2 RELATED WORK

2.1 Educational Psychology

Research in educational psychology has shown that content cannot simply be transferred from the lecturer to the learner [4]. Students need to "work" with the information given: comprehend it, make sense of it, relate it to prior knowledge and save it in their memory. Therefore, learning is defined as an active process [5][6]. Lecturers

can support the learning process by offering their students opportunities to actively deal with the presented learning contents. Research has shown that an active involvement of the learners in the lecture has a big impact on the success of learning activities [7].

Much research was done in the last years on how to improve the activity of students in classical lectures. One idea is to provide the students with possibilities of *rehearsing*: applying information after hearing it in a lecture enables the connection between concepts, makes the information meaningful, relevant, and contextual to the student [8]. Motivation research has shown that diversity can improve the students' motivation to learn: providing them variations in teaching methods makes it easier to concentrate; offering challenges and opportunities to succeed influences the students' commitment and self-efficacy expectations; possibilities to self-control the learning progress, but also ways of external control by the lecturer help the student to understand his learning deficits; informative feedback gives them a feeling of being supported and appreciated [9].

Therefore *activation* (especially in the sense of rehearsing) and *feedback* are substantial for the student learning process. Major challenges concerning the use of activating methods and feedback are time constraints as well as the size of the course. Lecturers usually do not have much time to test the students' understanding of a learning unit, especially in courses with hundreds of students.

One possible solution to meet all the mentioned requirements is the use of quiz questions via small handheld devices to provide additional communication functionalities and thus to improve the activity and motivation of the students. The quizzes can be used to ask students anonymously about their understanding or for

their opinion. Students can check their understanding of the course contents and apply the information in the quiz; lecturers get an insight in the students' learning progress and possible deficits. This enables lecturers to adapt the explanations and the course of the lecture according to the students' needs. Besides, students can be asked for their opinion concerning course contents. The method gives more reserved students the opportunity to participate. The results can be used to start a discussion (as an icebreaker) and directly ask further questions face-to-face.

Another way to use the quiz is to ask students about their satisfaction with the course. Because motivation increases if students feel involved and appreciated [9], a serious request for their satisfaction can highly influence the atmosphere in the classroom. Furthermore, the results can give important hints on the course concept and teaching activity. The lecturer can use this information to adapt his teaching activity, or explicitly state the reasons for the course design (often, the dissatisfaction is caused by a lack of communication and in-transparency of expectations, not by an insufficient course design).

In summary, the use of quizzes as a means of communication in lectures can have a positive impact on the learning success of the students, on the classroom atmosphere, and on the satisfaction on both sides. The development, as well as technical and economical challenges of traditional classroom response systems and our alternative are described below.

2.2 Technical Development

The aim of early systems like *Classtalk* [10] was to improve the involvement of every single student. The teacher transferred three to four *Classtalk* tasks per lesson to the students' devices, which were calculators,

organizers, or PCs at that time. Another early approach was the *ConcertStudeo* project which used an electronic blackboard combined with handheld devices [11]. It offered exercises and interactions such as multiple-choice quizzes, brainstorming sessions, or queries. The *Classroom Feedback System* (CFS) was designed for online feedback [12] and allowed students to post annotations directly on lecture slides.

Scheele et al. have developed the *Wireless Interactive Learning (WIL/MA)* system to support interactive lectures [13][1]. It consists of a server and a client software part; the latter runs on handheld mobile devices. The 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 before they can use the system.

Novel mobile devices not only support the visualization or playback of multimedia content like audio, text, images, or videos but also allow an easy interaction with the device [14][15]. HTML5 especially supports the visualization of graphical and multimedia content¹ in Web browsers. Although most of the technical challenges have been solved today, some questions still remain, e.g., how to create more intuitive user interfaces or how to visualize pictures or videos on the small screens of mobile devices without removing important content [16][17][18][19][20]. Liu and Chen [21] focus on the quality of audio and video communication in a mobile learning scenario.

Ijtihadie et al. [22] propose to use an offline Moodle learning management system. The system is implemented with HTML5 that supports an offline application capability.

¹ <http://www.w3.org/TR/html5/>

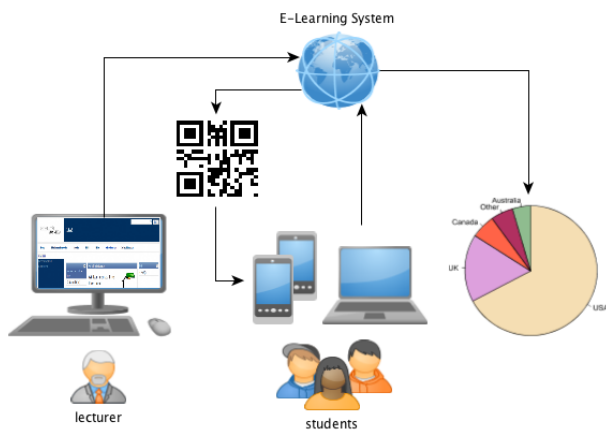


Figure 1: Mobile Quiz concept

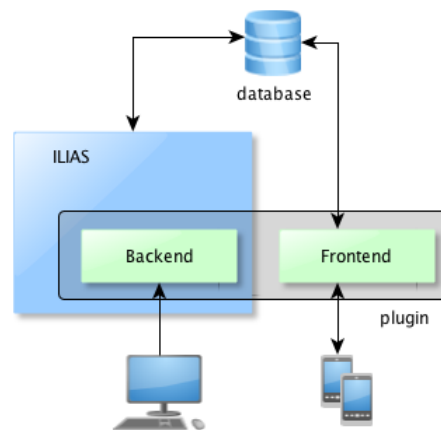


Figure 2: System architecture

Mehta et al. [23] 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. [24] present an online learning tool for the iPhone that allows students to answer quizzes anytime. Clunie et al. [25] present a platform that enables users to connect an Android phone to the content management system Moodle. The system supports features like alerts, chats, forums, or access to personal data such as grades. Ullrich et al. focus on mobile learning in developing countries [26]. They argue that a major advantage of using mobile devices in comparison to laptop or desktop computers is the high penetration rate of mobile phones in those countries. Their proposed system allows a large group of students to use a mobile device for interacting with teachers during a lecture.

We define three requirements for our *Mobile Quiz Application*: (1) No additional software should have to be installed on the mobile devices. (2) Almost all modern mobile devices should be supported so that no extra hardware has to be purchased. (3) The system should be integrated into the learning management system of the university.

None of the existing systems considers all these three requirements. In our opinion, it is much more suitable to require only a Web browser, and of course, every smartphone, notebook, or tablet PC has one. In addition, in recent years, learning management systems (LMSs) have become commonplace in universities, and thus an integration of the quiz tool into the LMS is reasonable.

3 SYSTEM OVERVIEW

Fig. 1 and Fig. 2 give a brief overview of our Mobile Quiz Application. It consists of two parts: a *backend* provides 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 potentially replace each one of these modules at a future point in time separately. The backend is implemented as a plugin for the university's e-learning platform ILIAS. Although the frontend is technically independent of ILIAS, it is delivered in the same software package, which simplifies the installation and maintenance of the system. Additional information about the concept of the Mobile Quiz Application can be found in [27][28].

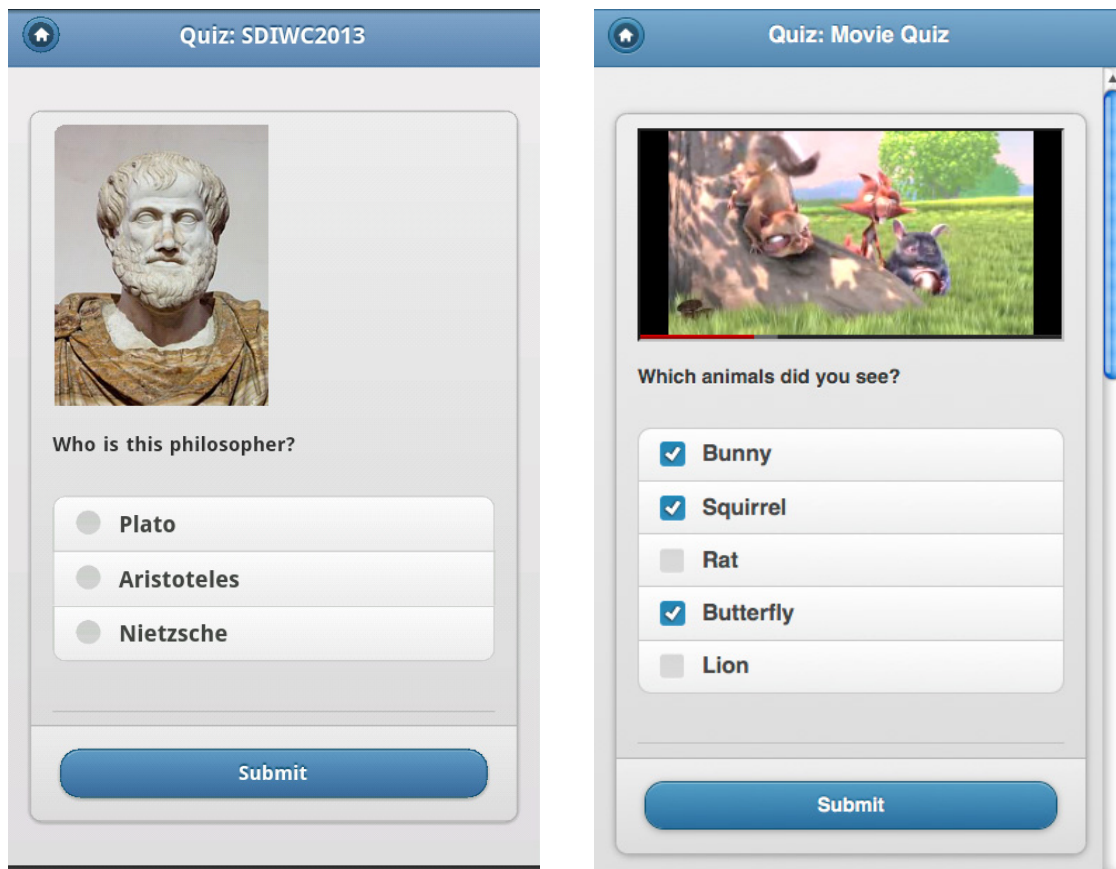


Figure 3: Examples of a picture quiz (left) and a video question (right).

3.1 The Lecturer's View

The *Integrated Learning, Information, and Work Cooperation System* (ILIAS) [2] is an open source e-learning software. It is 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 worldwide. One of its components already 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 of our lecturers are familiar with it. We thus decided to develop the quiz administration as a plugin for ILIAS. All the management activities, like creating questions, starting quiz rounds and visualizing the results can thus be done within ILIAS.

3.2 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 connect to the mobile quiz and to answer the questions. Furthermore, the



Figure 4: The QR code is displayed on the screen during a lecture.



Figure 5: Discussing the answers in the course.

application has to be robust regarding connection failures. We decided to implement our quiz as a Web application by using existing Web technologies based on the jQuery mobile Web framework. A main advantage of our approach is the high accessibility for a wide range of small mobile devices, as well as laptops, netbooks, and tablet PCs.

The use of Web technologies opens up many new possibilities. Although the quiz looks like a native smartphone application, the questions are presented on normal Web pages, opened by the devices' browser. Therefore, it is quite easy to include pictures, videos, and other media content. Fig. 3 (left) shows a question based on a picture. It is a referral to Wikipedia. The video in Fig. 3 (right) is directly embedded from YouTube. Unfortunately, most mobile browsers do not yet support the latest web technologies to the extent desktop browsers already do. If we used HTML5 3D technology, only a few students would be able to watch the content. Therefore, we currently only use web multimedia technologies that are already widely available for mobile browsers (e.g. pictures).

3.3 Quick Response Codes

To simplify the access to the quizzes we use *Quick Response Codes* (QR codes). They display the link to a specific quiz as a machine-readable image. Students can use their smartphone's camera and standard QR code reading software to access a quiz, without the need of manually typing in a link on the tiny keyboards of their mobile phones. QR codes are two-dimensional barcodes storing 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 a link to a web page. QR codes are often found in advertisements, linking to further information about a product. There are several standards, including ISO/IEC18004 [3] for the physical encoding, and a de facto standard for encoding URLs from NTT DoCoMo². The latter is optimized for fast readability, and it includes error correction to enhance its robustness. Fig. 4 and Fig. 5 show a QR code used in a lecture and the presentation and discussion of the results.

² <http://www.nttdocomo.com/>

4 EVALUATION OF THE MOBILE QUIZ TOOL

Although our system is designed for good usability and easy accessibility, we were confronted with several difficulties. The technical implementation of the QR code, the bandwidth requirements for the Wi-Fi network in the lecture room and the students' acceptance were the biggest technical challenges. First, we did some experiments for proving the concept: we examined the readability of the QR code in lecture rooms and did some trials in lectures with about 30 students. After these tests were successful, we lunched the Mobile Quiz Application as a regular plugin in ILIAS for every lecturer of our university to be used. Within the ongoing Fall semester we monitored pioneer lecturers, who were using the quiz, measured the network and did a questionnaire-based survey with about 250 students.

4.1 Evaluating the QR Code

We conducted experiments to evaluate the limits of the QR code technology. We measured the readability of codes with 30, 60, 90, and 120 encoded characters and four different error correction levels, using typical recent mobile devices (HTC Hero, HTC Desire HD, Samsung Galaxy S2, Iphone4 and Motorola Milestone). For scanning the QR code, we used *Barcoo*³ and *Barcode Scanner*⁴. The tests were done in one of our lecture rooms with 140 seats in normal daylight conditions in six distances of four and fifteen meters. When increasing the number of encoded characters or the level of error correction, the amount of black and white squares within the QR code increases,

and the size of each square shrinks. This impairs the 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 method of error correction. It is designed for burst errors, e.g., losing a corner of the code. However, this type of error is unlikely to occur when displaying the QR code on a projection screen. Fig. 6 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, and we implemented an URL shortener to keep the amount of characters as small as possible.

4.2 Load on the University Infrastructure

Besides the readability of the QR codes, we identified difficulties that were not so easy to handle. 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 (e.g. UMTS). Unfortunately, the Wi-Fi network at our university was not designed to serve more than a hundred parallel data connections in one room. Therefore, we were interested in the network load and delay caused by using our quiz tool.

First, we measured the load for one participant. In this case, a quiz with five plain text questions and three possible answers was used. The download to the device created about 240 Kbits of data, the upload for submitting the answers about 100 Kbits. This causes a total network load for the entire process of 340 Kbits. The largest part of the

³ <http://www.barcoo.com>

⁴ <http://code.google.com/p/zxing/>

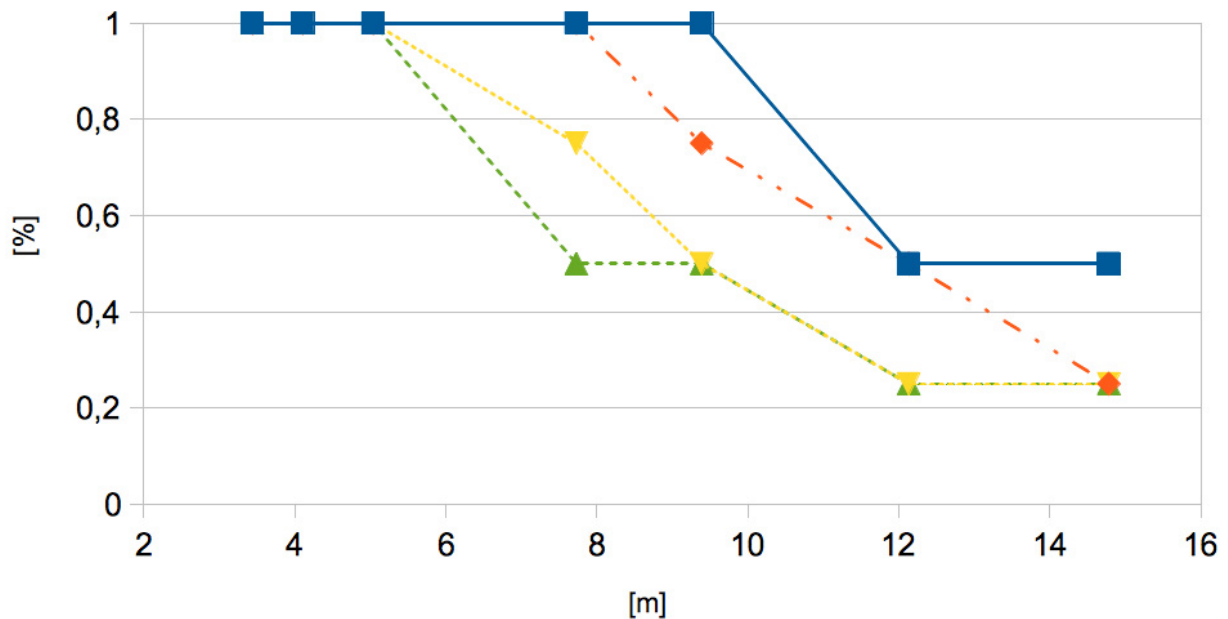


Figure 6: QR code readability with 30, 90, 150 and 210 encoded characters.

downloaded data consisted of pictures which were used for the design template on the phones and the jQuery-libraries.

We then measured the network load directly within the Wi-Fi access points during a quiz round. Fig. 7 shows the amount of data during an entire lecture with 139 students. The upload (blue) and download (red) is measured in megabits per second, arithmetically averaged over four seconds.

The quiz took place from 10:36 to 10:41. Only one numeric question was asked during the quiz round. 95 students participated, and 85 of them used the university Wi-Fi network.

When the quiz starts, the graph shows a peak up to 8 Mbit/s and goes down to about 3 Mbit/s. Comparing the rate to the average network load during the lecture, the quiz is easily recognizable. But regarding the maximum possible network load of 100 Mbit/s (IEEE 802.11n with MIMO) for our

university Wi-Fi, the maximum capacity of the Wi-Fi net is not utilized.

Unfortunately, the Wi-Fi network delay increases with an increasing number of clients [29]. 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. With about 85 students participating via WiFi we did not notice a significant impact on the network delay.

So far, we only examined quiz rounds with plain text questions. When using multimedia content, the network load will rise considerably. We intend to examine the impact in the future.

4.3 Mobile Browser Technology

Even if most HTML5 technologies are already quite common on desktop browsers, they are not yet available for the majority of mobile browsers. When using HTML5, more

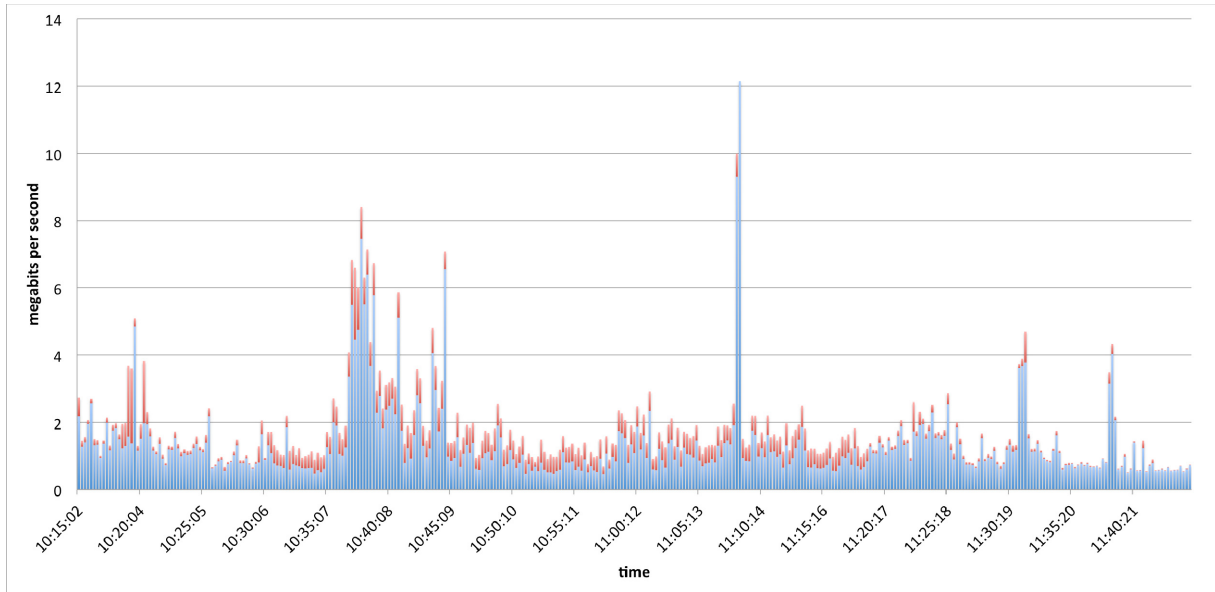


Figure 7: Network load during one lecture with a quiz at 10:36.

complex media content like videos and 3D-objects cannot be displayed by most of today’s smartphones. In current lectures, this type of content should thus be avoided. On the other hand, when creating a quiz for a remote video lecture, where most of the students participate via a desktop computer or laptop, videos and 3D objects wouldn’t make much difficulties.

Regarding the current speed of smartphone evolution, we are expecting a wide HTML5 support in the near future.

4.4 Usability and Acceptance

After we conducted a proof of concept within a small lecture with about 30 students, we evaluated the tool in two lectures with 253 students altogether.

The topic was “Business Economics”, and the course was held in two parallel lectures with about 130 students each. The students were asked to participate in a quiz every second week. We did not announce the evaluation

and let the students fill in a questionnaire at the end of the lecture. We also measured the network load as described in Section 4.2 above. Of the 253 students, 201 students participated in the quiz, 52 did not.

Table 1 shows the reasons for not participating in the quiz. With 62.7 %, most of the 52 students did not participate because they did not have their devices at hand. About 16 percent said that they wanted to participate but were not able to do so, mostly because of the unstable Wi-Fi connection. About 4 percent said the participation was too troublesome. Only 9.8 percent said that they do not have a suitable device.

Table 1: Reasons for lack of participation.

| Reason | % |
|--------------------------------|------|
| did not work | 15.7 |
| too troublesome to participate | 3.9 |
| brought no device with me | 62.7 |
| do not own a device | 9.8 |
| other | 7.8 |

The 201 participating students mostly participated with their smartphones (88.4%), 4 % used their laptops. Only one percent used an ordinary mobile phone and 6.6% used other devices like iPads.

Table 2: Distribution of devices.

| Device | % |
|----------------|------|
| smartphone | 88.4 |
| laptop | 4.0 |
| ordinary phone | 1.0 |
| other | 6.6 |

We wanted to know how fast and easy the quiz access was felt by the users and if students thought that the Mobile Quiz Application increased their motivation or the understanding of the lecture content.

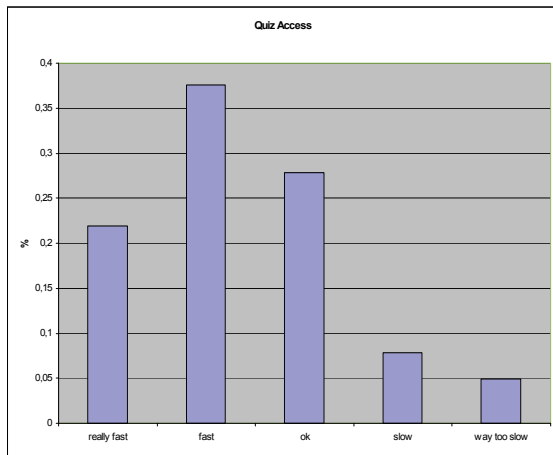


Figure 8: Speed of quiz access.

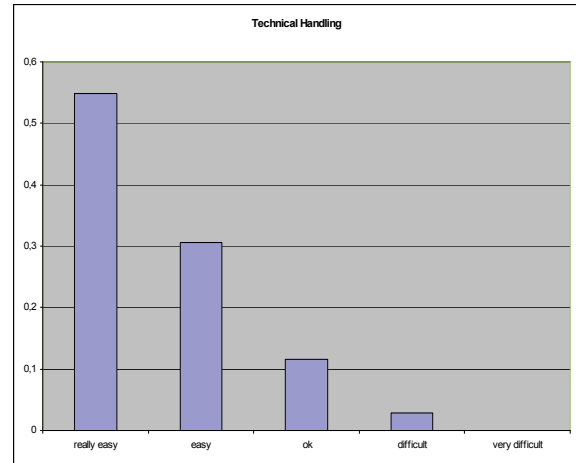


Figure 9: Ease of technical handling.

When asked about the technical difficulties, more than fifty percent said that the Mobile Quiz Application is really easy to handle (Fig. 9). Other students answered that the handling was ‘easy’ (31%) or ‘ok’ (12%). Only three percent found it difficult to participate in the quiz

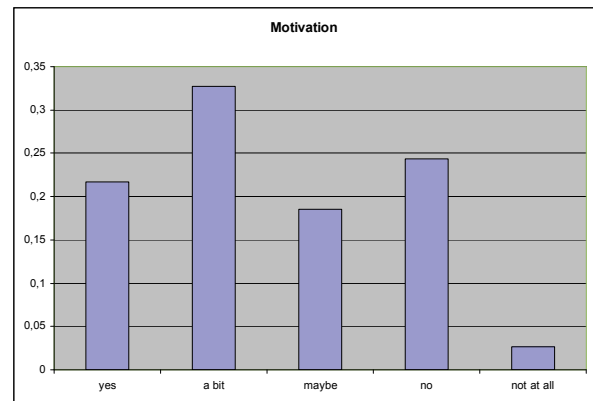


Figure 10: Increased motivation.

Furthermore, we asked how the students estimated the impact on motivation, content understanding, and increasing the interest in the lecture.

Fig. 10 shows that fifty percent of the students said that the quiz increased their motivation. 19% did not know if there was

an impact on their motivation, and 27% said that their motivation was not increased.

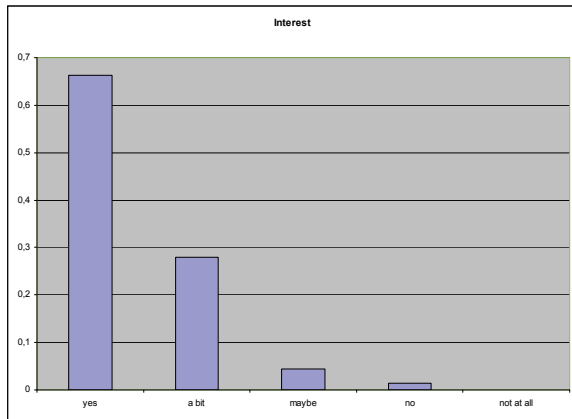


Figure 11: Quiz increased interest in lecture content.

When asked if the quiz does increase the interest in the lecture, 66% answered with ‘yes’ and 28% with ‘a bit’ (Fig. 11). Only 1% said that the quiz does not increase their interest in the lecture.

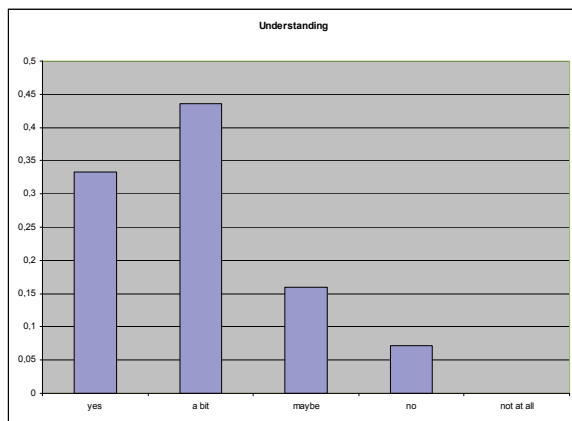


Figure 12: Quiz supported understanding of the lecture content.

About 76% of the students thought that using the quiz in lectures helped them to understand the lecture content better. Only 7% said it had no impact on the understanding (Fig. 12).

Finally, we asked if the students wanted to see such quizzes more often. 68% answered with ‘yes’, 26% said ‘maybe’ and only 6% did not want them more often.

5 DISCUSSION

Our experiences show that the Mobile Quiz Application is feasible in practice, and it fits our requirements. The measurements on the network load showed that our Wi-Fi infrastructure is sufficient; lectures with hundreds of students can be handled. Unfortunately, some lecture rooms without Wi-Fi connections do still exist in our university. In this case the students have to use the Internet connection via their mobile network provider or a dedicated, temporary Wi-Fi network has to be set up for the duration of the quiz.

Using a QR code for the URL of a quiz round is a feasible approach. Many students are accustomed to their usage, and the number of people using QR codes increases. Our results also show that the majority of the students are familiar with the use of their devices and even with new applications like the Mobile Quiz.

The readability of the QR code from a projection screen is acceptable, but it strongly depends on the quality of the smartphone’s camera. In most of the lectures, there were some students who could not read the QR code correctly and had to type in the URL manually. But the access to the quiz is significantly simplified when using QR codes. Overall, students seem to be quite satisfied with the use of the QR codes.

Considering the question ‘did the quiz make the lecture more interesting for you?’, 94 % of the students agreed (66 % ‘yes’, 28 % ‘a bit’). 77 % of the students agreed on the question ‘did the quiz help you to understand

the lecture content?’ (33 % ‘yes’, 44 % ‘a bit’). This result supports our assumption that applying and actively using the information given by the lecturer supports the student’s learning process.

The answers to the question of motivation have a high variance. One possible explanation is the little weight of a small tool like the mobile quiz in a complex course design. Another reason is that learning motivation stems from many different aspects, e.g., interest in the topic, teaching skills of the lecturer, the student’s mood, and the classroom atmosphere. Nevertheless, the strong agreement on the question whether the quiz should be used more often during lectures implies the high interest in and acceptance of the tool.

Talking with the lecturers who used the quiz so far has clearly shown the relevance of formulating questions in a suitable way. Especially in the humanities, it is highly challenging to formulate questions with numeric, multiple or single choice options that test the understanding of the course contents. When it comes to questions that test the deep understanding of concepts or theories, lecturers often need additional support, e.g., by educational staff developers. To improve the usability of quizzes in the humanities, we want to add an extension of the quiz’ answer formats to open answers, which are transferred on the classroom screen in real-time. This enables the students to comment the current lecture and allows the lecturer to react accordingly.

Another fundamental aspect is the question when and how often to use the quiz. In some cases it has shown to be useful to apply the quiz mainly at the beginning of a classroom session to repeat the contents of the previous session or to assess previous knowledge. In other cases, such as game theory lectures, the quiz can easily simulate market situations and

therefore be used in the input phase of a course.

Finally, there is no standardized best way to use a quiz that would be valid for every kind of course, but experience has shown that most students in different class sizes and different disciplines are very grateful and supportive concerning the application of the mobile quiz.

6 CONCLUSION AND OUTLOOK

We have designed and implemented an electronic quiz system called *Mobile Quiz* which can be operated via the university’s e-learning platform. Students use their own web-enabled devices, e.g., smartphones for answering the quiz questions. Our experiences show that over 90% of our students own a suitable device for participating in a quiz. A QR code is used to ease the initial connection to the quiz. We evaluated its readability in a typical lecture room, and measured the impact of the mobile quiz on the university’s Wi-Fi infrastructure. Both evaluations showed that our design is well feasible in practice.

We extended our approach by the possibility to add multimedia content like pictures and videos to the questions and the answers. But complex HTML5 technologies (3D objects and videos) should not be used in today’s lectures because most mobile browsers do not yet support them.

Our *Mobile Quiz* only requires an Internet connection and visual sight of the QR code (or the URL). Therefore, it is even usable in remote video lectures or in a combination of remote and local lectures, without any additional effort for the teacher.

The user evaluation and experience shows that lecturers and students rate the system very well. With this first insight we can assume that the *Mobile Quiz* enhances students’ motivation and learning progress.

Nevertheless, lecturers need support regarding the reasonable usage of the quiz. Further development of the tool is needed, but all participants seem to be very supportive, and they are all looking forward to a full rollout.

In future work, we will investigate the educational impact for different disciplines and subjects in more detail. We will closely work together with our lecturers and try to find out which consequences the use of the quiz has on the teaching and learning activity. In further steps, we plan to design teaching recommendations and extend the e-learning consulting for our lecturers. Considering the functionality of the *Mobile Quiz Application*, we want to extend the quiz with more types of questions and answer formats, as well as an improvement of the support of multimedia content. We will also add an offline mode, where the QR code is printed into the lecture notes so that the students can participate in the quiz from home and directly get back their individual results.

7 ACKNOWLEDGEMENTS

We want to thank Stephan Schulz for the implementation of the first prototype of the quiz tool and our student co-workers Maximilian Wich, Neslihan Tasci and Dominik Campanella for their dedicated support.

8 REFERENCES

- [1] Scheele, N., Wessels, A., Effelsberg, W., Hofer, W., Fries, S. Experiences with Interactive Lectures - Considerations from the Perspective of Educational Psychology and Computer Science. *International Conference on Computer Supported Collaborative Learning*, 2005
- [2] ILIAS website – <https://www.ilias.de> , accessed August 2012
- [3] ISO/IEC. Information technology - Automatic identification and data capture techniques - QR Code 2005 bar code symbology specification. Technical report: ISO/IEC 18004:2006
- [4] Biggs, J.: Teaching for Quality Learning at University. (2nd ed.). The Society for Research into Higher Education & Open University Press, Maidenhead, UK (2003).
- [5] Honebein, P. Seven goals for the design of constructivist learning environments. In B. Wilson (Ed.), *Constructivist learning environments* (New Jersey: Educational Technology Publications), 1996, pp. 17 – 24.
- [6] Wilson, B.; Cole, P. , A review of cognitive teaching models, *Educational Technology Research and Development*, 39, 1991, 47–64.
- [7] Ramsden, P. (1992). Learning to teach in higher education, London: Routledge, 1992
- [8] Bligh, D. A.: What's the Use of Lectures? Jossey-Bass, San Francisco, CA (2000).
- [9] Deci, E. L., Ryan, R. M. The Paradox of Achievement: The Harder You Push, the Worse It Gets. In: Aronson, J. (ed.) Improving academic achievement. Impact of psychological factors on education, pp. 61-87. Academic Press, Amsterdam (2002).
- [10] Dufresne, R.; Gerace, W.; Leonard, W.; Mestre, J.; Wenk, L., Clastalk: A classroom communication system for active learning, *Journal of Computing in Higher Education*, 1996, 3–47.
- [11] Dawabi, P., Dietz, L., Fernandez, A., Wessner, M., Concert-Studeo: Using PDAs to support face-to-face learning, *Proc. of Computer Support for Collaborative Learning*, 2003, 235–237.
- [12] Anderson, R. J., Vandegrift, T., Wolfman, S., Yasuhara, K., Promoting interaction in large classes with computer-mediated feedback, *Proc. of Designing for Change in Networked Learning Environments*, 2003, 119–123.
- [13] Kopf, S., Effelsberg, W. New Teaching and Learning Technologies for Interactive Lectures. *Advanced Technology for Learning (ATA)*, ACTA Press, vol. 4, no. 2, 2007, pp. 60 – 67

- [14] Dufourd, J.-c.; , "LASER: The lightweight rich media representation standard [Standards in a Nutshell]," *Signal Processing Magazine, IEEE*, vol.25, no.6, pp.164-168, November 2008
- [15] Rogers, Y.; Connelly, K.; Hazlewood, W.; Tedesco, L.; "Enhancing learning: a study of how mobile devices can facilitate sensemaking". *Personal Ubiquitous Comput.* vol.14, no.2, pp. 111-124, February 2010.
- [16] Laakko, T.; Hiltunen, T.; , "Adapting Web content to mobile user agents," *Internet Computing, IEEE* , vol.9, no.2, pp. 46- 53, March 2005
- [17] Kiess, J.; Guthier, B.; Kopf, S.; Effelsberg, W.; SeamCrop: changing the size and aspect ratio of videos. In *Proc. of the 4th Workshop on Mobile Video (MoVid '12)*, 2012, pp. 13-18.
- [18] Kopf, S.; Kiess, J.; Lemelson, H.; Effelsberg, W., "FSCAV: Fast seam carving for size adaptation of videos," *Proc. ACM international conference on Multimedia (MM '09)*, pp. 321-330, 2009.
- [19] Kopf, S.; Haenselmann, T.; Kiess, J.; Guthier, B.; Effelsberg, W.; "Algorithms for video retargeting". *Multimedia Tools Appl.* vol.51, no.2, pp. 819-861, January 2011.
- [20] Rijsselbergen, D.; Poppe, C.; Verwaest, M.; Mannens, E.; Walle, R.; "Semantic Mastering: content adaptation in the creative drama production workflow". *Multimedia Tools Appl.* vol.59, no.1, pp. 307-340, July 2012.
- [21] Liu, C.; Chen, W.; "The effectiveness of the handheld devices based on mobiles learning. " *Proc. of the 2nd International Conference on Interaction Sciences: Information Technology, Culture and Human*, pp. 400-405, 2009
- [22] Ijtihadie, R.M.; Chisaki, Y.; Usagawa, T.; Cahyo, H.B.; Affandi, A., Offline web application and quiz synchronization for e-learning activity for mobile browser. *IEEE Region 10 Conference TENCN*, 2010, pp.2402–2405
- [23] Mehta, S.M.; Spanias, A.; Thiagarajan, J.J. ,Work in progress — An interactive web-based quiz that uses the java-DSP editor to enhance student learning experience, *IEEE Frontiers in Education Conference (FIE)*, 2010, pp.T2G-1-T2G-2
- [24] Tabata, Y.; Yin, C.; Ogata, H.; Yano, Y. An iPhone quiz system for learning foreign languages, *Intl. Asia Conf. on Informatics in Control, Automation and Robotics (CAR)*, vol. 3, 2010, pp.299-302
- [25] Clunie, G.; Serrão, T.; Gómez, B.; Riley, J.; Crespo, S.; Rangel, N.; Rodríguez, K.; Braz,, L.; Castillo, A.; Barraza, O.; Developing an Android based learning application for mobile devices. *Proc. of the 6th Euro American Conference on Telematics and Information Systems*, pp. 239-245, 2012
- [26] Ullrich, C.; Ruimin Shen; Ren Tong; Xiaohong Tan; , "A Mobile Live Video Learning System for Large-Scale Learning - System Design and Evaluation," *Learning Technologies, IEEE Transactions on* , vol.3, no.1, pp.6-17, Jan.-March 2010
- [27] Schön, D.; Kopf, S.; Schulz, S.; Effelsberg, W.; Integrating a Lightweight Mobile Quiz on Mobile Devices into the Existing University Infrastructure. In *Proc. of World Conference on Educational Media and Technology (EdMedia)*, 2012.
- [28] Schön, D.; Kopf, S.; Effelsberg, W.; "A lightweight mobile quiz application with support for multimedia content," *e-Learning and e-Technologies in Education (ICEEE)*, 2012 International Conference on , pp.134-139, 24-26 Sept. 2012
- [29] Xiao, Y. An analysis for differentiated services in IEEE 802.11 and IEEE 802.11e wireless LANs, *Intl. Conf. on Distributed Computing Systems*, 2004, 32 – 39