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HomeQuiz: Blending paper sheets with mobile self-assessment tests

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Abstract: This article describes *HomeQuiz*, an effective approach to blend classical paper learning material with a digital mobile self-assessment system. In times of tablets and smartphones, many students still use printed lesson scripts and exercise sheets. But many applications for supporting students with self-assessment and testing already exist. The aim of our work is to close the gap between paper sheets and digital assessment. Therefore, we took the experiences from our classroom quiz tool and upgraded it with a self-assessment functionality. By printing QR codes on documents like exercise sheets or lecture scripts and linking them to content related questions, we are now able to support students with a real-time feedback of their knowledge and providing the lecturers detailed information about the learning success of their students. To enable this functionality, we have developed a plugin tool connected to our learning management system. A major advantage our approach is the fact that we do not need additional software or hardware, for students and lecturers.

Introduction

Many lecturers are faced with the problem of students' insufficient preparation and post procession of their courses. Additionally, students usually give little feedback if asked for questions concerning the previous course. They do not dare to ask, afraid to embarrass themselves. In other cases, they are not able to articulate their gaps in knowledge because they cannot identify them without concrete tasks. As a consequence, the lecturer does not know the real bias between the students' base of knowledge and his own impression of it. A common solution is to provide homework and weekly exercise sheets. This gives students the opportunity to practice, evaluates their knowledge base, and points out their gaps.

Within the last years, many systems were developed to digitalize and support traditional learning in classrooms and at home. Learning management systems offer testing modules and audience response systems (ARS) are widely known. In regard to the increasing spread of mobile phones, applications for blended and mobile learning were released in many places. Research in classes has shown that students appreciate the usage of, e.g., ARS for making courses less boring (Uhari, Renko & Soini, 2003; Tremblay, 2010) and for enhancing their learning (Uhari, Renko & Soini, 2003; Kopf, Scheele, Winschel & Effelsberg, 2005). Especially younger students and those with a high text messaging frequency perceive higher benefits of the ARS activity (Tremblay, 2010). In addition, ARS provide lecturers with an insight of their students' knowledge within class.

But often, ARS came with the drawback of an increased effort in preparation and an expensive access to the applications. Commercial applications have to be bought and lecturers have to learn how to handle the new software. Mobile applications have to be installed and the authentication often slows the access.

Our aim is to transfer the benefits of using ARS within classrooms to students' preparation and rework phase at home, without adopting their drawbacks. Therefore, we blended the classical paper learning materials with modern digital self-assessment tests. We enhanced our well-accepted ARS *MobileQuiz* (Schön, Klinger, Kopf & Effelsberg, 2012c) with a self-assessment functionality. The novel *HomeQuiz* system uses well known *Quick Response Codes* (QR codes) to function as a link to the digital test. The idea is to print these codes on paper learning materials (Fig. 1). Students invoke it by using their own web-enabled mobile devices, e.g., a smartphone, tablet, or laptop. The QR code allows them to effortlessly switch from paper script to a digital test belonging to current learning topics.

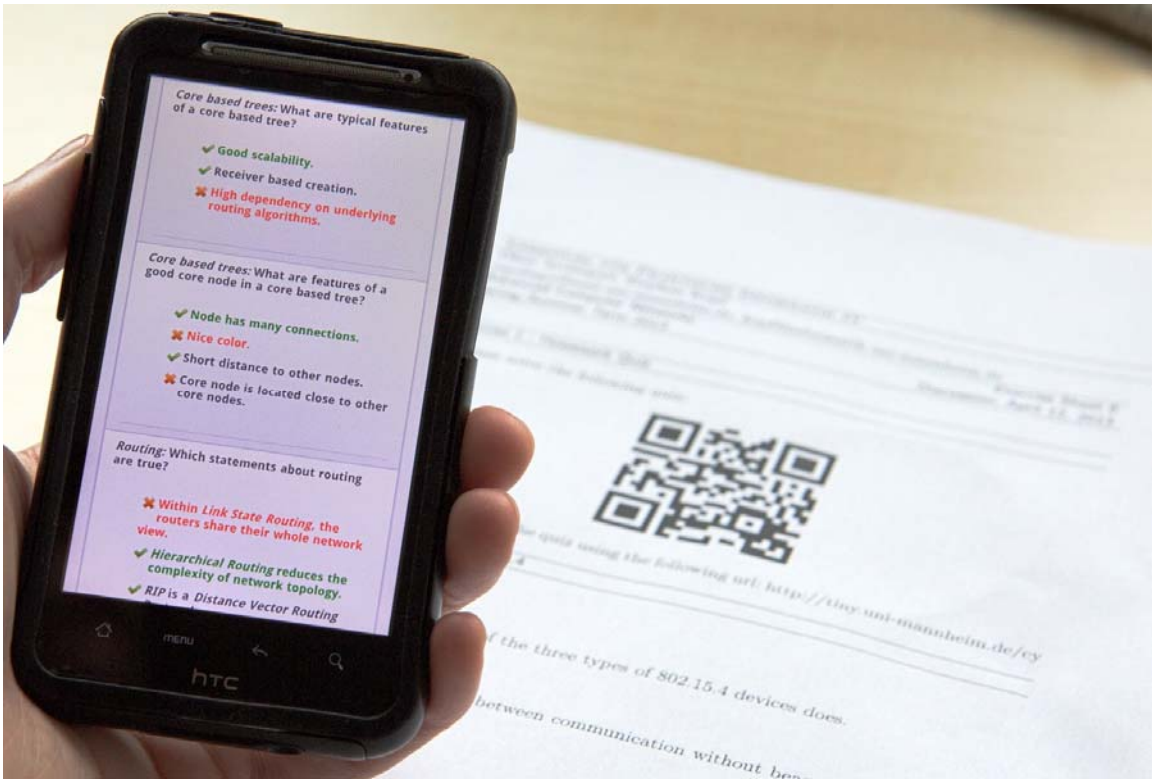

Figure 1: Result of a quiz round displayed on a phone. The QR-Code printed on an exercise sheet is visible in the background.

By enhancing an already used functionality of our learning management system we could maintain a high acceptance through avoiding a long training period for our lecturers. The idea to enable the existing ARS questions for home assignment was initially requested by students. We therefore measured the acceptance and satisfaction of the new tool by interviewing students of two different courses.

Our article is structured as follows: First, we will give an overview about related studies and systems. After giving a brief description of our system and the technologies used, we show the students' evaluation as well as the lecturers' views and discuss the results. The article ends with a conclusion and an outlook on future developments and research.

Related Work

The main aim of teaching is to help students in their understanding and learning of the teaching contents. Research has shown, that activity improves learning (Biggs, 2003). Therefore, lecturers should offer students the opportunity to actively deal with the course contents. One way is to give students questions and tasks to deal with. Additionally, fostering intrinsic motivation can enhance learning. Intrinsic motivation improves if the student has a feeling of competence and autonomy (Deci & Ryan, 2000). Autonomy is given in self-regulated learning settings, e.g. in preparation and rework of courses. Using lecture recordings is a typical scenario which gives students a large amount of autonomy about when and where to learn (Lampi, Kopf, Benz & Effelsberg, 2007, 2008). To achieve a feeling of competence, a student needs self-control mechanisms that help him to clarify his state of knowledge and possible deficits. Therefore self-assessment tools are useful for the student learning process.

Using interactive assessment tools offers students and lecturers the advantage of immediate feedback on the responses (Ibabe & Jauregizar, 2009). Peat and Franklin (2002, in Ibabe & Jauregizar, 2009) showed that the usage of interactive self-assessment could enhance learning when feedback is given. Ibabe & Jauregizar (2009) showed that students, who do not take part in voluntary tasks regularly and have a low motivation to learn, often take part in interactive self-assessment. This fact confirmed that interactive self-assessment systems with immediate feedback are perceived as attractive and useful. As we use the mobile devices of students we expect students to realize even more of a "fun factor" in the usage.

Several ARS have been developed and evaluated in the last years. One of the first systems is *Classtalk* (Dufresne, Gerace, Leonard, Mestre & Wenk, 1996), which used calculators to answer simple quizzes. More complex interactions like multiple-choice quizzes or queries are supported with *ConcertStudeo* (Dawabi, Dietz, Fernandez & Wessner, 2003). In previous work, we developed the *WIL/MA* system (wireless interactive learning at the University of Mannheim) to enhance the interactivity between students and teacher during a lecture (Scheele, Wessels, Effelsberg, Hofer, Fries, 2005; Kopf & Effelsberg, 2007). As a major drawback, this system used JAVA and client software had to be installed on the students' devices. Mehta et al. carried out a similar approach (Mehta, Spanias & Thiagarajan, 2010). They developed a JAVA tool that supports quizzes and video lectures and is connected to a learning management system.

More similar to our *HomeQuiz* system is the work proposed by Teng et al. (Teng, Chen & Lee, 2011). They use QR codes on printed materials in the context of enhancing English reading comprehension. They observe that questions improve the students' learning success whereas using the QR codes to link to additional learning materials does not give any benefit. Compared to the previous work, our system provides additional functionality, is fully integrated into our learning management system, and students from different disciplines regularly used and evaluated it. Another novel concept based on QR codes has been modeled by Yfantis et al. (Yfantis, Kalagiakos, Kouloumperi & Karampelas, 2012). They discussed many details about how to use QR codes in e-learning but a real system has not been implemented and evaluated yet.

In previous work, we developed the *MobileQuiz* as a lightweight application, which used QR codes displayed on screen and integrated it into the learning management system at our university (Schön, Kopf, Schulz & Effelsberg, 2012a). Novel functionality like the support of multimedia content (images and videos) was added and network load on the universities infrastructure and acceptance was evaluated in detail with hundreds of users (Schön, Klinger, Kopf & Effelsberg, 2012c). Compared to our previous work, *HomeQuiz* now connects classical paper based learning (lecture slides, exercise sheets) with electronic quizzes, which are still fully integrated in our learning management system.

The Application

The application consists of two parts: the lecturers' view for administrating the questions and the students view for participating in the testing rounds. Both access data from the same database but are technically independent. The lecturers' view is implemented as a plugin for the university's e-learning platform ILIAS. Although the students' view is technically independent of ILIAS, it is delivered in the same software package, which simplifies installation and maintenance of the system.

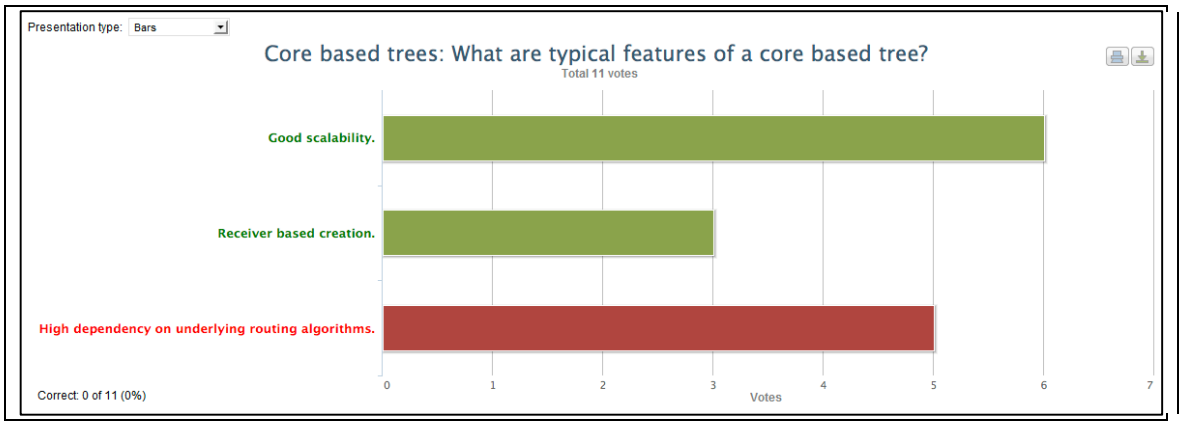

Figure 2: Screenshot of a bar chart showing the results of a question in the lecturers view.

The Lecturers' View

The *Integrated Learning, Information, and Work Cooperation System* (ILIAS[1]) is an open source e-learning software. It is published under the terms of the GNU General Public License and written in PHP. It is maintained and extended by an increasing number of participants worldwide. 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 does not provide a quick and easy link to the questions. Furthermore, it is not designed to offer anonymous quizzes or support mobile devices. However, being a productive system, most of our lecturers are familiar with it and it provides standard functions like rights and roles management. We 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 be done within ILIAS.

The lecturer can easily create a new quiz, which is composed of single choice-, multiple choice- or numerically answered questions. Each question is assigned to several possible answers. When the lecturer starts a new round, a new URL and an associated QR code are automatically generated. The lecturer can start as many rounds of the same quiz as necessary. The answers of every round are cumulated separately. A round can be in three different states: *active*, for the usage as ARS, *inactive*, which means it is closed, and *direct feedback* for home self-assessment. Students can participate only once in an active round and do not see their personal answers, whereas the direct feedback rounds can be performed many times and the individual results are shown to the student immediately after submitting the answers.

Independent of the state of the round, the lecturer can examine the cumulated answer results (Fig. 2) and display them to the audience. Until now, histograms, bars, and line charts are implemented.

The Students' View

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 quiz and to answer the questions. We decided to implement our question view as a Web application by using existing technologies based on the jQuery Mobile Web framework[2]. A main advantage of our approach is the high accessibility for a wide range of 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 and opened by the devices' browser. Therefore, it is quite easy to include pictures, videos, and other media content. Unfortunately, most mobile

[1] www.ilias.de
[2] http://jquerymobile.com

browsers do not yet support the latest web technologies to the extent desktop browsers already do. We considered using HTML5 3D technology, but choosing this technology would reduce the number of students who are be able to watch the content. Therefore, we only use media that is typically supported by mobile browsers (e.g., pictures).

We only implemented questions with *single choice*, *multiple choice*, and *numeric answering format*, although many other types were conceivable. But students are well used to these kinds of questions and these types can easily be answered via a smartphone's touch surface.

Quick Response Codes

We use *Quick Response Codes* (QR codes) to simplify quiz access. QR codes display the link to a specific quiz as a machine-readable image (Fig. 1). Students can use their smartphone's camera and default QR code reading software to access a quiz, without the need of manually entering a link on the tiny keyboards of their mobile devices. 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/IEC 18004:2006 for the physical encoding, and a de facto standard for encoding URLs from NTT DoCoMo[3]. We used the latter, which is optimized for fast readability and includes error correction to enhance robustness.

Evaluation

We selected two different courses for a test usage of the *HomeQuiz*. After the test we conducted a survey with the participating students and asked the lecturers about their opinion.

Course 1 (ACN): The lecture and tutorial of "Advanced Computer Networks" (ACN) is attended by approx. 70 students on master level. ACN is one of the computer science fundamentals and students typically participate in this course during second semester of the master program. The students already used the *MobileQuiz* during the lectures and some students asked for an offline version of the quizzes to repeat some topics. A quiz consisting of four questions was added to an exercise sheet. Students were asked during the next exercise to fill out the evaluation form about this *HomeQuiz*.

Course 2 (Literature): "Introduction to German Literature – Part 2" is attended by 18 students on bachelor level. The function was explained shortly and a sheet of paper with the QR tag and the URL to the quiz were given to the students (as it was a test usage of the functionality shortly after the development, we were not able to embed the QR-tag and the URL in the regular paper script). Students were asked to use the quiz function up to the next session. In the next session, a paper questionnaire was handed out and directly answered by the students.

Table 1: Participation in the HomeQuiz

	Did you use the quiz?	Did you try to answer all questions?
Course 1 (ACN, n=46)	89.1 %	77.3 %
Course 2 (Literature, n=14)	50.0 %	70.0 %

Survey results

In course 1, 46 questionnaires were collected (cf. Table 1). 76.7 % of the participants could conduct the quiz without technical problems. 18.6 % of the students had a few problems; in 4.7 % of the cases the quiz did not work. When given a list of possible problems, results were as follows: "barcode reader did not work" (4.3 %),

[3] Leading japanese cell phone carrier (http://www.nttdocomo.co.jp/english/).

"QR-code unreadable" (2.2 %), "access very slow" (4.3 %) and 15.2 % of the students voted for "other", not precisely characterized problems.

Above 75 % of students agreed or strongly agreed, that their motivation to prepare the course content was increased (Fig. 3). Above 80 % answered, that the quiz increased their interest in preparing the course content. About 70 % agreed, that the quiz helped them to recognize deficits in understanding the course content and at least 50 % were motivated to ask more questions in the following course.
51 % strongly agreed to the statement, that they want to see such quizzes more often in the future. 40 % agreed to that and less than 10 % disagreed or strongly disagreed.

The questionnaire ended with an open question concerning further comments or improvement proposals. Students listed that a quiz should cover only one particular topic to be less confusing and that they wanted to see the overall answers to compare themselves to the other students.

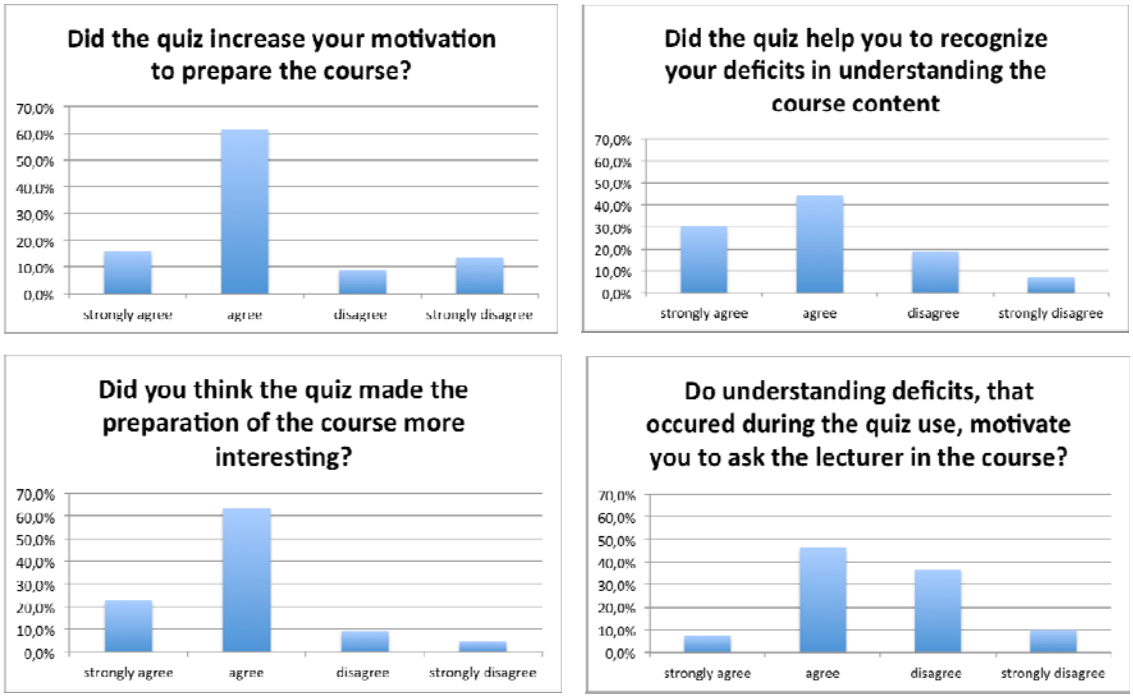

Figure 3: Results of student survey in group 1 (informatics).

The results of the survey in course 2 were less positive. 14 students attended the session and completed the questionnaire. Only 7 used the *HomeQuiz* and gave us their opinion.
6 of 7 students used the quiz without any technical problems. One student indicated little problems because of a malfunctioning barcode reader.
All 7 students disagreed (2) or strongly disagreed (5) concerning the question "did the quiz increase your motivation to prepare (or respectively rework) the course?". On the question, if the quiz made the preparation/rework more interesting, 2 students agreed, whereas 1 disagreed and 4 strongly disagreed. Detected understanding deficits did not motivate students to ask the lecturer in the course (5 disagreed, 2 strongly disagreed). At least, 3 students confirmed that the quiz helped them to detect deficits in understanding, whereas 1 disagreed and 3 strongly disagreed.
On the question, whether students think the quiz should generally be used more often for preparation and rework, 1 student strongly agreed, 1 agreed, 4 disagreed and 1 strongly disagreed. Asked, if more questions in one single quiz round are preferred, 2 students strongly agreed, 1 agreed, 2 disagreed and 2 strongly disagreed.

In summary, the results of course 2 are – besides the question of representativeness – rather negative concerning the *HomeQuiz*. Possible reasons and conclusions will be discussed in the following section ("Discussion").

Lecturers' View

We also asked both lecturers for feedback. In the case of ACN, the lecturer's most important benefit is the feedback about how well a topic is understood by his students. This is especially useful when the *HomeQuiz* is used in exercise sheets, because difficult questions can be discussed and explained in the following lesson. It also seems to be important that the questions of the quiz match well to the content of the current exercises. The students of ACN are not forced to prepare the exercises. Therefore, the quiz especially helps to motivate some of the more passive ones. The additional effort for inventing good questions is seen as a time-consuming problem. But it will decrease in future, because of the reusability of already existing questions.

The lecturer of course 2 describes the *HomeQuiz* as a useful instrument because it combines the advantages of classical e-learning with the advantages of our regular *MobileQuiz*[4]: as e-learning itself is traditionally independent of time and space and gives immediate, teacher-independent feedback, *HomeQuiz* offers lecturers the opportunity to constrain the timeline and to give personal feedback in the following course session. The lecturer can show the aggregated results and discuss them with his students. The single-player mode of the quiz itself is complemented by interactivity with the teacher and other students. The teacher can explain detected understanding deficits in personal contact. The asked lecturer further states that for his special seminar the *HomeQuiz* could not fully meet the requirements, as the format of the quiz was not appropriate concerning the learning objectives of the course. Students are to practice practical skills and therefore a one-dimensional answering format is not useful, even if some basic and elementary principles can be formulated in single and multiple choice formats. He summarizes that the *HomeQuiz* is a "nice tool" that at least can make teaching more interesting.

Discussion

Our results show that the students and lecturers accept the new functionality and predominantly like to use it for verifying the students' state of knowledge. Above 75 % of the students in course 1 perceived an increased motivation and interest in course preparation. Above 70 % of them say that the quiz helped them to recognize their knowledge deficits and at least 50 % were motivated to ask the lecturer about the deficits in course. There are various possible reasons for the latter: maybe students can identify their problems in understanding when given feedback about the correct and incorrect answers by the system and do not need additional support by the lecturer. Moreover, some of them maybe are still afraid to ask the lecturer and thereby embarrass themselves. The result could also hint on alternative learning strategies: students presumably ask their fellow students or try to find the solution to their problem within books or the Internet. Still, the interactivity in class grows significantly, if 50 % of the participants are motivated to ask further questions.
Finally above 90% of informatics students want the *HomeQuiz* to be used more often, which shows the high acceptance of the instrument.

Students of group 2 seem to be far more critical, concerning the usefulness of the quiz. Despite the lacking representativeness of this questionnaire, students could be rather dismissive because of the missing link between learning objectives and quiz questions (as mentioned by the lecturer, see section "Evaluation"). Presumably, they easily realize that the quiz usage does not directly help them to achieve the learning objectives. Additionally, the results could strengthen our assumption that quiz tools with the given answering formats are more useful in "hard sciences" or in courses with a high level of factual knowledge than in courses were discourse and practical skills are focused (Schön et al. 2012c).

The improvement proposals were rather useful. One student stated that one quiz should only cover one particular topic. If this approach is didactically useful in itself could be discussed controversially. But the

[4] *MobileQuiz* bases on the same system as *HomeQuiz*. It is used during the teaching session and has no direct feedback function. The lecturer displays the results after the quiz round and discusses them immediately.

comment surely hints on the relevance and importance of formulating reasoned questions. The wish to compare their result to other students gives us useful hints: students are interested in their distance to the mean state of knowledge. Additionally, the publication of the results, e.g. in the following course session, gives the lecturer the possibility to comment on the state of knowledge of his students, to investigate problems in understanding (e.g. by asking further questions) and to give further explanations.

Other benefits of the function, e.g. in comparison to *MobileQuiz*, can be the time saving towards performing a quiz within course time and the lecturer's possibility to use the results for adapting the content of the following lesson. He can analyze the quiz results and realize students' problems in understanding. But, lecturers and students mostly appreciate the ARS interruption within a lesson as a didactical method for reactivating and motivating the audience.

Despite the promising results, the value of the quiz strongly depends on the quality of the asked questions. This is a considerable effort, which varies with the contents nature. Additionally, the tool itself is constrained: for example, lecturers cannot determine if the number of votes corresponds the number of participants, as one student could vote more than once.

The usage of *HomeQuiz* also raises the question whether the participation in the quiz should be graded or not.[5] Taras (2003) states that grading such tasks could undermine the main function of the quiz: students should be enabled to explore the contents, to make errors, and to identify their gaps in understanding without being afraid of worsening their grades. Therefore, the traditional educational constraint has to be accepted: *HomeQuiz* (as all other tools in creating a learning environment) is an offer – students themselves are responsible for using it or not.

Conclusion and Future Work

HomeQuiz has proven to be a useful instrument for interactive self-assessment. It allows students to examine their gaps in knowledge and give the lecturer the opportunity to react accordingly. Students say that they are willing to ask more questions in course and have a higher motivation to prepare courses. Fast accessibility and easy arrangement within the existing learning management system are important prerequisites for this result. Despite the time saving by collecting students' state of knowledge before the lesson and not during it, home self-assessment should be seen as addition and not as replacement to an ARS. The direct didactical benefits of performing an ARS are not compensated.

Furthermore, the tool doesn't improve teaching by itself. It has to be embedded in an elaborated learning environment. One special challenge is the formulation of useful and effective questions, which depends heavily on the nature of the topic. Therefore, the development and implementation of the quiz has to be followed by support and advise for the users.

We consider further approaches for adjusting the way of questioning to fit to sciences with a higher amount of discourse and practical skills.

[5] Which is not yet possible with the current version of our tool.

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