This is a preliminary version of an article published by
Schön, D., Yang, L., Klinger, M., Kopf, S., Effelsberg, W.:
On the Effects of Different Parameters in Classroom Interactivity Systems on Students.
Proc. of World Conference on Educational Multimedia, Hypermedia and Telecommunications (EdMedia), pp. 497-505, June 2015.

On the Effects of Different Parameters in Classroom Interactivity Systems on Students

Daniel Schön, Licheng Yang, Melanie Klinger, Stephan Kopf, Wolfgang Effelsberg
Department of Computer Science IV, Educational Development
University of Mannheim
Germany
{schoen|kopf|effelsberg}@informatik.uni-mannheim.de, klinger@ssl.uni-mannheim.de,
yang@pi4.informatik.uni-mannheim.de

Abstract: Classroom Response Systems (CRS) are often used in higher education lectures. They help to activate students and to get a deeper insight on the students' knowledge base and on their opinion on currently discussed topics. Many different systems were created, offering a similar amount of functionality. We thus investigate what the important parameters of such systems are, and how they influence the students' behavior. Therefore, we consider classic response systems as well as systems with a higher amount of interactivity. In a first step, we have defined eight possible parameters, like the usage of pictures or a progress bar. We did a field study in thirty six lectures comparing the impact of the different parameters. As expected, the overall satisfaction with CRS is very high but we have obtained surprising results with particular parameters. We present the most interesting results and give a suggestion on which parameters are useful for an investigation in greater depth.

Introduction

Classroom Response Systems (CRS) are systems that allow lecturers to interact with their students by using clickers or mobile devices as a means of communication. A special software tool or a learning management system provides the lecturer with the possibility to ask questions that are answered by the students via clickers or on mobile devices, such as smartphones. Depending on the used application, question and answer formats can vary in shape and logic. Many systems offer single and multiple choice question formats, numeric question formats and the integration of pictures and videos into the questions.

Research has mostly focused on the question whether students liked the CRS, and if effects on the learning success of the students are recognizable (e. g., Fredericksen, 2006; Heaslip et al., 2014). In this paper, we go beyond the usual studies: We ask which CRS parameters can be identified, how they influence the students' activity, and how they should be designed to be as user-friendly as possible. For this purpose, we do not want to limit the CRS usage to a quiz or audience feedback, but also consider live experiments and other possible learning scenarios which are designed for being used in large classrooms and on the students' mobile devices (see for example a Likert scale evaluation in Figure 1). For this purpose, we have used the prototype of a new system developed at our university, the *MobileQuiz2*. It was especially designed to easily create new learning scenarios and modify parameters in an already existing one without touching the source code. Due to the enhanced variety of possible learning scenarios, which do not limit themselves to a plain response, the *MobileQuiz2* evolved from a standard CRS to a classroom interactivity system.

For the first turn, we concentrated on classic *multiple choice feedback* scenarios that differ in structure and appearance. For example we analyzed the effects of a progress bar and of a different color scheme. We initially named eight parameters and defined a hypothesis on how they will influence the students' behavior. We created twelve different learning scenarios to get a qualitative feedback on every parameter and checked our hypothesis in over twenty parallel lectures. The students attended a scenario and were asked for their opinion immediately afterwards.

This paper is structured as follows: first we outline related work in the fields of education and technology and introduce the system *MobileQuiz2* and its features. Afterwards, the study's design and results are presented and discussed. Finally, we end with a conclusion and an outlook on future work.

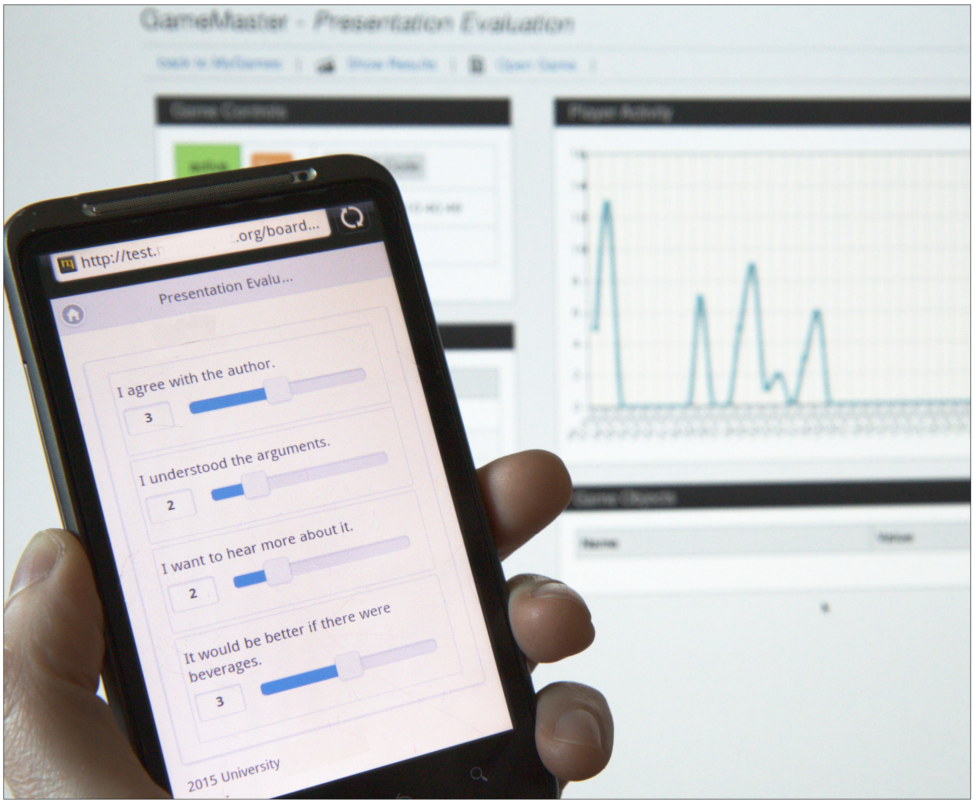

Figure 1: Using a Likert scale scenario with sliders on a mobile device. The background shows the user activity chart of the lecturer's view.

Related Work

CRSs are one way to provide interactivity between lecturer and students, even in large classes. Lecturers can ask questions on the understanding of lecture contents or on the students' opinions and immediately get an insight into the students' perception. Thereby, lecturers can react on students' responses and adapt their teaching activities if necessary: explanations can be repeated, other illustrating examples can be given, or - in the case of questions on the students' opinions - discussions can be started.

Much of the earlier work deals with the question of the usefulness of CRSs: students have a higher learning success in courses using a CRS (Uhari et al., 2003), and rate these courses less boring (Tremblay, 2010). They feel more involved (Barnett, 2006) and appreciate the opportunity to compare their knowledge to other students' knowledge (Barnett, 2006; Fredericksen, 2006; Heaslip et al., 2014). Interactive self-assessment that is followed by feedback can enhance the learning even more (Peat and Franklin, 2002, in Ibabe and Jauregizar, 2009), and even students with a low motivation often take part in interactive self-assessment (Ibabe and Jauregizar, 2009). Additionally, the anonymity of the system raises the students' willingness to participate (Heaslip, 2014). Even the attendance rate can be raised by the use of CRS (MacGeorge et al., 2008; Fredericksen, 2006).

The development and regular use of CRSs goes back several years. *Classtalk* (Dufresne et al., 1996) is one of the earliest systems; it uses calculators to answer simple quizzes. *ConcertStudeo* (Dawabi et al., 2003) added more complex interactions such as multiple-choice questions. In our earlier work, we developed and used the first *MobileQuiz* system to enhance the interactivity between the students and the teacher during a lecture (Schön et al. 2012a). As a major drawback, this system used JAVA and had to be installed on the students' devices. At this time, JAVA wasn't yet supported by the majority of devices.

Mehta et al. proposed a similar JAVA tool that supports quizzes and video lectures (Mehta et al., 2010). In addition, the students can connect to the learning management system. More recent work on CRSs focuses on an easier accessibility when using smartphones (Yfantis et al., 2012). The proposed system uses QR codes to reduce the problem of typing links addresses to web pages with a smartphone. The paper discusses many details about how to use QR codes in e-learning. Kim et al. proposed a CRS integrating social media by using Twitter (Kim et al., 2014). A teacher presents questions at unexpected moments during the lecture. An awarding system is included that not only validates whether an answer is correct but also the time for answering the question.

Most existing CRSs do not support collaboration between students. Malandrino et al. (2014) proposed a system that enables collaboration by allowing discussions between students. Possible difficulties with specific topics could be identified more easily in this way. Another problem Lucke et al. (2013) tackle is the time it takes for students to answer quizzes and to explain the correct answers. Using a quiz typically has the effect that less content is covered in the lectures. However, the flipped classroom concept where students watch the lecture recordings at home can provide the lecturers sufficient time for discussing difficult questions during the presence phases.

The previous version of the *MobileQuiz* was implemented as a lightweight application, which used QR codes displayed on the lecturer's screen and in the projection (Schön et al. 2012b). The system supported multimedia content (images and videos) and was completely integrated into the learning management system at our university. The MobileQuiz2 is now widely used and its performance and acceptance was evaluated in detail with hundreds of users (Schön et al. 2012c). Over time, more and more recommendations and ideas for improvements were proposed by the teachers and students who regularly used the system. However, the modifications or recommended expansions of the system required programming skills and thus a computer scientist.

Due to the limited flexibility of the system, we decided to create a novel, more flexible application, the MobileQuiz2. Whereas the older *MobileQuiz* has the typical functions and parameters of a modern CRS (e.g., web-based implementation, access via QR code and dynamic charts) it is limited to the usual question types and answers. The main focus is on single and multiple choice questions, numeric questions, and the embedding of multimedia content like pictures or videos. But the scenario is bound to the lecturer asking for a feedback of his students, providing exactly the implemented question elements.

We have received many requests from lecturers to add further question types, which differed only slightly from the already existing functionality. Therefore, we decided to create an abstract model, which uses a small set of basic elements to be able to easily describe richer learning scenarios. Our fundamental idea is that every scenario has the same basis of HTML elements like buttons, input fields, number fields and text fields on the students' displays. They are different only in their layout, visibility and background logic.

We then divided the process of developing a learning scenario into five phases: definition of the scenario, description of an entity, performance of a tool round (an actual classroom activity), presentation of the results and an eventual analysis. We are now able to realize different classroom scenarios within one tool without manipulating the source code. The scenarios range from simple audience feedback, single choice questions and twitter walls up to complex, interactive game theory experiments and full marketplace simulations. The teacher does not need any programming skills anymore to change already existing scenarios or to create completely new ones.

With that range of designing the details of classroom interaction the question rose how to best use elements and parameters to support learning and motivation of the students. We thus conducted the experiment described in the next section.

The Study

We evaluated our hypothesis in real classroom settings at our university. We modeled twelve different learning scenarios within the *MobileQuiz2* to investigate the effects of different scenario parameters on the students' acceptance. The used scenarios were mostly multiple-choice feedback quizzes with differences in their structure and appearance. Among other things, one of the scenarios investigated the differences between an open text answer format and predefined single choice answers. In this work, we only describe six parameters in more detail, as font size and system performance did not result in useful insights.

Figure 2 shows a scenario with only one text answer, a progress bar and a button to browse forward. But the same topic could also be presented without a progress bar and all questions and answer fields directly visible. Figure 3 shows a multiple-choice question with an image, whereas the alternative scenario used a mere textual description. Our goal was to get a first qualitative feedback on those different scenarios to assess possible fields of further research. We wanted to get an impression on which parameters hold the potential to be rated as user-friendly and therefore support students' learning behavior.

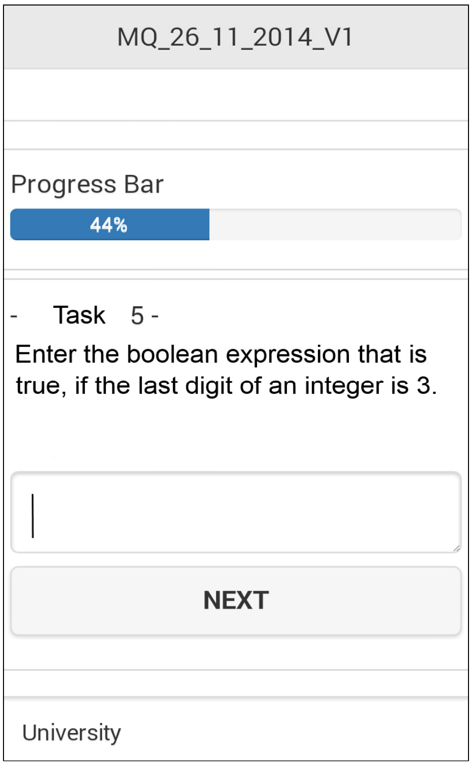

Figure 2: Scenario with progress bar and open text answer.

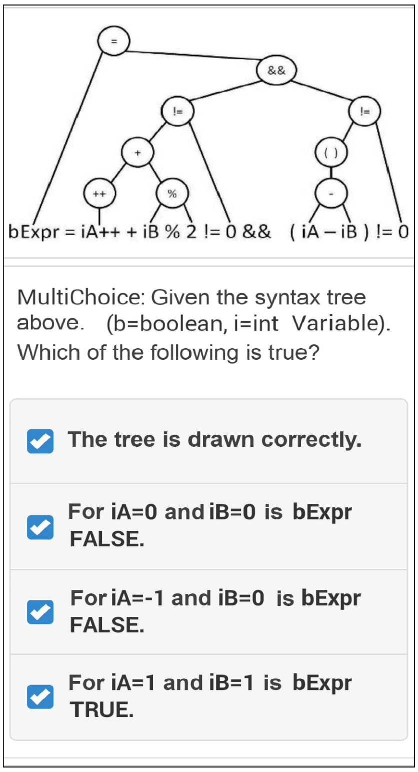

Figure 3: Scenario with several open text fields on one page.

All participants of the study were enrolled in the course Computer Science I which is taught every second semester at the University of Mannheim. Approximately 200 students take part in the final exam. Most of them study business informatics (1st semester), business mathematics (5th semester) or business teaching (5th semester). The course comprises two weekly lectures, a weekly exercise and eight tutorials. The weekly exercise class lasts 90 minutes and has an estimated number of 40 to 60 participants. The eight weekly tutorials also last 90 minutes. The eight tutors are responsible for approximately 25 students in each tutorial. The attendance is not mandatory.

We used the exercise and the tutorials for our scenarios. To motivate the students to attend the scenarios the lecturer solved questions or tasks from old exams. We created the scenario by implementing the quiz questions in compliance with the investigated parameter. Subsequently, the students took part on the scenarios. The exercise instructor or the tutors lead the discussion of the tasks.

There were five exercises and three tutorial days (all weekly tutorials took place on the same day of the week), with 15 minutes each available for our case study. When we planned our quiz, we scheduled about ten minutes for the question session since the students needed time to access the quiz website via the QR code. In the first exercise, we tested the *MobileQuiz2* for its basic functionality for the case study environment. After this test, we configured the tool so that it was ready for the real case study. At the beginning of the study, we informed all students that they would be participating anonymously in a study to investigate various parameters in scenarios, without letting them know which parameters we wanted to investigate.

The scenarios during the large exercises contained the same questions for all students because it would have been difficult to divide all participants in the same room into two large groups, as they would easily recognize the investigated parameter by comparing their scenario to the scenario of their neighbors. However, in the tutorials we had the perfect opportunity to divide the students into two groups as they do not meet each other during the lecture time. Thus, it was possible to compare the results. For example, the students of tutorial 1, 3, 5 and 7 formed the group A and used the first parameter in a text version. The students of the tutorials 2, 4, 6 and 8 obtained a graphical version. The number of students in the tutorials varied slightly due to the voluntary participation. As a result, the two groups were not quite balanced. Moreover, the participants who showed up in the weekly tutorials were not always the same. In order to balance the number of participants, we arranged the tutorials in a way that we got two groups of almost the same size.

Students were asked for their perception and opinion of each scenario directly after its usage. This means that they used two different scenarios one after another: first the quiz on the lecture contents with the varied design parameters, then a simple evaluation quiz on the precedent quiz. The latter used a four-point Likert scale from “very pleasant” to “very unpleasant”. We used the four-point Likert scale to ensure a forced choice of the participants.

	Parameter	**Description and Hypothesis**
1	Graphical vs. Textual Content presentation	The same question is presented to students by either graphics or text. We assumed that students prefer a graphical presentation. Long texts would demotivate the students, and consequently decrease the task quality.
2	Multiple Choice with all true or false	The question is offered with several choices, where the choices are either all true or all false. We assumed that students will need substantially more time to answer all questions since their intuitive beliefs make them unsure.
3	Textual Answers with Special Characters	The questions have the same content, but the students have to answer them in the form of either text or Java-Code. We assume that answering with specials characters will force the students to make a greater effort due to the switching of keyboard.
4	Color	The application used a different color scheme for the background, text field, text, etc. We assumed that the students would be more motivated by pleasant colors to participate in the scenarios.
5	Progress Bar	Several questions in a list are either presented with or without a progress bar which showed the questions yet to come. We expected that students would be more impatient without a progress bar or could not concentrate for a longer time.
6	Grouped Content	All questions are not shown on the same page, but grouped according to the content. The students could navigate to target groups from the main menu. We assumed that through structural grouping the students would get a better orientation and thus answer the questions better.

Table 1: Selected parameters and hypothesis of the students’ behavior.

Results

Almost every student participating in the experiment also participated in the evaluation. We got about thirty statements per parameter. We evaluated the handling of the prototype and the acceptance of the respective scenario. Additionally, we collected qualitative user feedback about the positive and negative aspects of every scenario by open questions at the end of the evaluation.

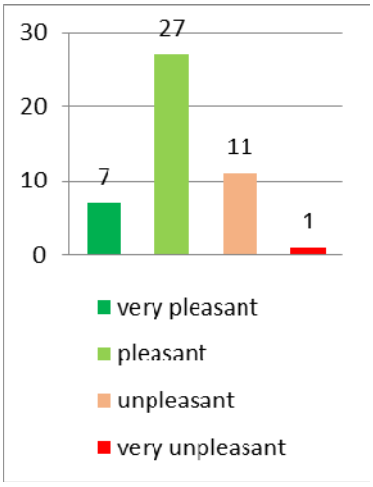

Figure 4: Multiple choice question with picture.

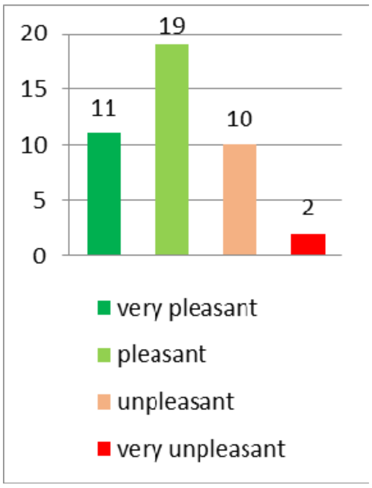

Figure 5: Multiple choice with text description.

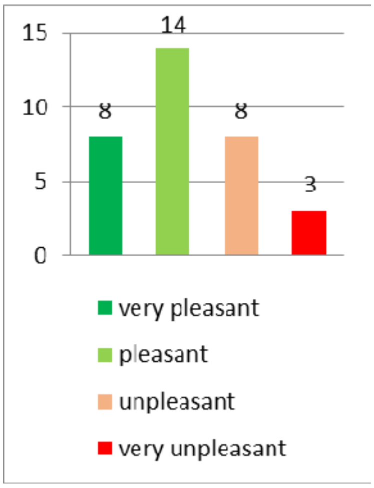

Figure 6: Multiple choice with only true answers.

Parameter 1: Graphical vs. textual content presentation

The quiz in this scenario asked questions about classes in the programming language JAVA. One group got a typical class diagram represented as a figure, whereas the other group got a description of the class relations. As shown in Figures 4 and 5, there was not much difference in user experience between the two scenarios. We expected the picture scenario to be favored but about two third of the students rated both scenarios as pleasant or very pleasant. Respectively, one third was not pleased with both scenarios. As reasons they stated the clarity in both cases. They had to scroll up to the picture and down to the answers for every question. In the other case, they mentioned the pure amount of description text as too much and visually unstructured.

Interestingly, the group with the picture answered questions about the relationship between the classes more precisely whereas the other group was superior in questions about the class details.

Parameter 2: Multiple Choice with only true or false choices

The scenario showed a picture and several multiple choice questions. The evaluation showed a similar result as the first one. About two thirds of the students were pleased with the experience. As expected, they took more time to finish the questions compared to the first one, and the level of noise in the classroom grew. The students mentioned that it should be announced explicitly when no choice is correct, as they were very confused with that possibility.

Parameter 3: Textual answers with special characters

Figure 7 shows the results when students had to use source code within their textual answer. Source code contains many special characters and is more difficult to enter on a mobile phone. Usually, special characters like square brackets and the ampersand are on a second or third page of a mobile phone keypad and therefore not directly visible. But more than about the input of special characters, the students complaint about the size of the input text field as they thought it was small to keep the overview over open and closed brackets.

Parameter 4: Striking color scheme

In this scenario we changed the color scheme of the quiz into bold green, blue and pink. The students showed mixed reactions. We assumed more severe protest but were surprised by the results. Beyond the fact that the look was not professional and pink ”was no serious color”, we also got many reactions stated that the bold colors supported a better overview of the quiz; more than half of the students liked the color change.

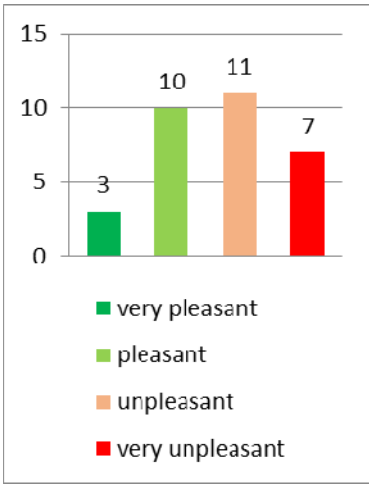

Figure 7: Task with source code to answer.

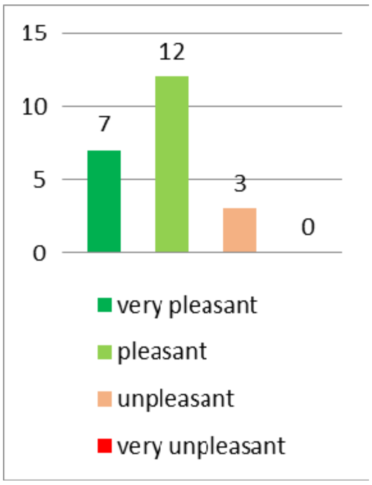

Figure 8: Scenario without progress bar.

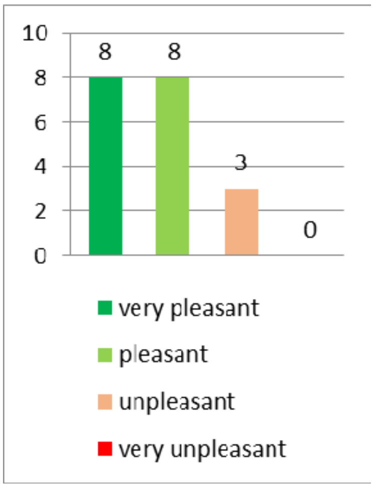

Figure 9: Scenario with progress bar.

Parameter 5: Progress bar

This scenario displayed only one multiple choice question and a 'next'-button on the page. With a click on this button the next question was shown. One group also got a progress bar, showing the amount of questions yet to come. Figures 8 and 9 show similar positive feedback of both groups. They stated the increased clarity of the quiz with only one question at a time. Students without the progress bar claimed that they wanted to see the number of questions. Both groups also asked for a 'back'-button as it was not possible to return to the previous question.

Parameter 6: Grouped content with index

In preparation of the upcoming exam, this scenario covered all topics of the course. About five questions of every topic were grouped together, and the students could choose between the topics via an index page as seen in Figure 11. After completing a topic, they could return to the index page and go to another set of questions. The overall submit button was only available if at least one topic was completely answered. They really liked this setup in regard of the upcoming exam, as everyone could attend to his/her favored field.

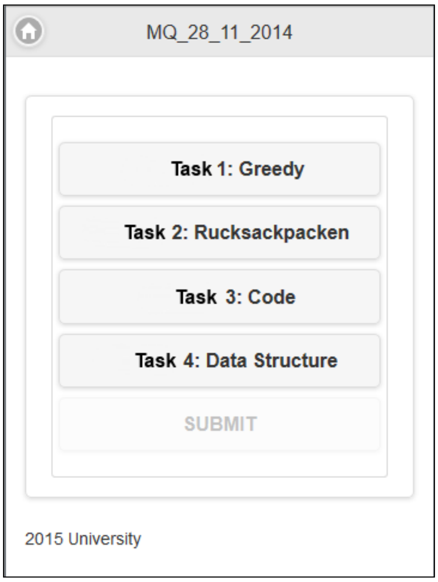

Figure 10: Screenshot of scenario 6 that uses an index view.

Discussion

As digital natives, today's students are confronted with a wide range of website and app designs. On the one hand, this lets them easily handle the use of QR codes and mobile apps, on the other, it makes them very sophisticated in the evaluation of user-friendliness and design aspects. As students are used to professional products in apps and web pages, they are, for example, very impatient concerning loading times. During our study, the most basic requirement was conformingly the system's performance. Students mentioned the performance as important in every scenario, especially in scenarios with a bad performance due to a high network delay.

Students are used to so many variations of applications that they somehow adapted to concentrate on the contents first. Therefore, the lacking outrage on color variations is comprehensible. They focused on a clear overview of the required task. They wanted to quickly recognize important content information and the clickable elements. Following the usability premise: "Don't make me think!" (Krug, 2000), they did not want to have to explore the functionality of the tool first. Thus, they preferred layouts supporting the clearness of the application, including colors with a high contrast.

They also wanted to overlook their range of possibilities as quickly as possible and did not want to scroll the page to discover more answer possibilities, respectively scrolling back up to inspect the given information more deeply. They also liked the scenarios with only one question visible, where they could navigate to the next question with a forward button or an index page. The usage of a progress bar better supports the overall overview, but only with a small margin.

Using figures to visualize a problem may not be supportive in every case. Especially when asking complex and detailed questions, students often prefer a textual problem description with textual structure elements like bold and italic.

As mentioned in the second scenario, students got irritated when the known elements were not used in the usual way. When none (or every) given choice was true they became uncertain and started to discuss this problem with their neighbors.

Concerning the limitations of our study, students were not used to a meta-analysis of their learning material, especially if the analysis focuses on design differences. Students were told about the purpose of the meta-analysis, but surely had problems describing their perception on minor design differences. Additionally, students could not directly compare the parameter variations, e. g. progress bar versus no progress bar. In future research we plan to adapt the study design and let the students directly compare different parameter designs. This could give additional insights in the students' parameter perception.

Conclusion and Future Work

In this paper we provide an insight on which parameters influence the students' acceptance of classroom response systems. We investigated eight possible parameters (of which six were discussed) in a pilot study with around 150 students of a practical informatics course in nine weekly lectures over two months.

Our results showed that an acceptable overall system performance is the fundamental requirement. Without a fast and flawless operation, students will criticize this first. Another highly noticed parameter is the overall clearness of the task. The students get annoyed if they had to scroll the page to get to all available information or answer possibilities of the current scenario. In favor of this overview, they even accept striking color schemes.

Technically, the *MobileQuiz2* has reached a stable phase. We are now introducing it to a larger number of lecturers and will offer training by our didactic experts. Additionally, we are including the tool into our central learning platform. We will use the new possibilities to further investigate different learning scenario parameters on the lecturers' capabilities and the students' acceptance. We then have to widen the user range to non-informatics students to get a more representative and reliable data base.

References

Barnett, J. (2006). Implementation of personal response units in very large lecture classes: Student perceptions. In *Australasian Journal of Educational Technology* 22(4), 474-494.

Dawabi, P., Dietz, L., Fernandez, A., Wessner, M. (2003). Concert-Studeo: Using PDAs to support face-to-face learning, In *Computer Support for Collaborative Learning*, 235–237.

Dufresne, R.; Gerace, W.; Leonard, W.; Mestre, J.; Wenk, L. (1996). Classtalk: A classroom communication system for active learning, In *Journal of Computing in Higher Education*, 7, 3–47.

Fredericksen, E. E. (2006). *Can a $30 Piece of Plastic Improve Learning? An Evaluation of Personal Responses Systems in Large Classroom Settings*. URL: http://hdl.handle.net/1802/2474

Heaslip, G.; Donovan, P.; Cullen, J. G. (2014). Student response systems and learner engagement in larger classes. In *Active learning in higher education* 15(1), 11-24.

Ibabe, I. & Jauregizar, J. (2009). Online self-assessment with feedback and metacognitive knowledge. In *Higher Education* 59, 243-258.

Kim, Y., Jeong, S., Ji, Y., Lee, S., Kwon, K. H., Jeon, J. W. (2014). Smartphone Response System Using Twitter to Enable Effective Interaction and Improve Engagement in Large Classrooms, *IEEE Transactions on Education*.

Kopf, S. & Effelsberg, W. (2007). New Teaching and Learning Technologies for Interactive Lectures. In *Advanced Technology for Learning Journal*, ACTA Press, Vol. 4 (2), pp. 60 – 67.

Krug, S. (2000). Don't make me think! : a common sense approach to Web usability. Indianapolis, Ind. : Que.

Lucke, T., Keyssner, U., Dunn, P. (2013). The use of a Classroom Response System to more effectively flip the classroom, *IEEE Frontiers in Education Conference,* 491-495.

MacGeorge, E. L.; Homan, S. R.; Dunning, J. B. Jr.; Elmore, D.; Bodie, G. D.; Evans, E.; Khichadia, S.; Lichti, S. M.; Feng, B.; Geddes, B. (2008). Student evaluation of audience response technology in large lecture classes. In *Educational technology research and development* (56), 125-145.

Malandrino, D., Manno, I., Palmieri, G., Scarano, V., Filatrella, G. (2014). How quiz-based tools can improve students' engagement and participation in the classroom, *International Conference on Collaboration Technologies and Systems,* 379-386.

Mehta, S. M., Spanias, A., Thiagarajan, J.J. (2010). Work in progress — An interactive web-based quiz that uses the JAVA-DSP editor to enhance student learning experience. In *IEEE Frontiers in Education Conference*.

Scheele, N., Wessels, A., Effelsberg, W., Hofer, W., Fries, S. (2005). Experiences with Interactive Lectures - Considerations from the Perspective of Educational Psychology and Computer Science. In *Computer Supported Collaborative Learning*.

Schön, D., Kopf, S., Schulz, S. & Effelsberg, W. (2012a). Integrating a Lightweight Mobile Quiz on Mobile Devices into the Existing University Infrastructure. In *Proc. of World Conference on Educational Media and Technology* (EdMedia)

Schön, D., Kopf, S. & Effelsberg, W. (2012b). A lightweight mobile quiz application with support for multimedia content. In *International Conference on e-Learning and e-Technologies in Education*, pp.134-139.

Schön, D., Klinger, M., Kopf, S. & Effelsberg, W. (2012c). MobileQuiz – A Lecture Survey Tool using Smartphones and QR Tags. *International Journal of Digital Information and Wireless Communications* 2(3), p. 231-244.

Tremblay, E. A. (2010). Educating the Mobile Generation – using personal cell phones as audience response systems in post-secondary science teaching. In *Journal of Computers in Mathematics and Science Teaching* 29 (2), 217-227.

Uhari, M., Renko, M. & Soini, H. (2003). Experiences of using an interactive audience response system in lectures. In *BMC Medical Education* (3).

Yfantis, V., Kalagiakos, P., Kouloumperi, C., Karampelas, P. (2012). Quick response codes in E-learning. In *Education and e-Learning Innovations*, 1-5.