Chances and Risks of Using Clicker Software in XL Engineering Classes – from Theory to Practice

Valerie Stehling¹, Ursula Bach¹, René Vossen¹, Sabina Jeschke¹
¹ IMA - Institute of Information Management in Mechanical Engineering
ZLW - Center for Learning and Knowledge Management
IFU - Institute for Management Cybernetics
Faculty of Mechanical Engineering RWTH Aachen University (Germany)
¹E-mail: valerie.stehling@ima-zlw-ifu.rwth-aachen.de, ursula.bach@ima-zlw-ifu.rwth-aachen.de, rene.vossen@ima-zlw-ifu.rwth-aachen.de, sabina.jeschke@ima-zlw-ifu.rwth-aachen.de

Abstract
Teaching and learning in XL-classes is a huge challenge to both lecturers as well as students. While lecturers face the difficulty of speaking to a mostly loud and very heterogenic audience, students often lack the opportunity of being an active participant in class. To counteract these difficulties and give the opportunity of immediate feedback, an audience response system has been introduced in the class of information technology in mechanical engineering at RWTH Aachen University.

In a previously published paper [1] the theoretical background has been outlined and presumptions have been drawn. The described redeployment of a lecture of the mentioned size was expected to bring about an enhancement of the quality in teaching of professional knowledge. It was also supposed to foster the often desired shift from teaching to learning. Now, after a first trial and evaluation of the method, these presumptions can be tested.

In this paper clicker questions from the lecture and their results are the groundwork that allow for a review of the evaluation of the first trial using clicker software in class. Results shall then allow for a comparison of the intended goals with the actual outcomes from the students’ point of view. In addition to that, feedback and ideas for improvement through the evaluation of the “further comments” section by the “users” themselves can be gathered. The results of the analysis will then allow for an adjustment and improvement of the concept and may in the future give support to lecturers of other XL-classes that intend to implement an audience response system in their own lecture.

Keywords
Large classes, clicker software

1. Initial Situation Outlines
RWTH Aachen University is a highly ranked university [2] especially in the fields of engineering – mechanical engineering, electrical engineering, industrial engineering etc. It attracts a vast amount of students each semester which in the past has led to lecturers facing the challenge of having to teach a rising number of students each semester [1]. In the lecture “Information Management in Mechanical Engineering I” there are up to 2000 students each semester. This circumstance is partly a result of educational policy that subsequently reduces schooling from 13 to 12 years and thus leads to a vast increase in enrolment.

With such a large number of students it is impossible to give all of them the chance to actively take part in the lecture. Nor is it possible as in smaller seminars to get an idea of the knowledge background of your audience. Audience response systems (ARS) such as hardware clickers or in this case clicker software, however, offer the possibility to interact and thus get a chance of immediate feedback of the students even in large lectures. Therefore, the system was implemented and run in a first trial in the described lecture during the summer semester of 2012. At German universities the use of clicker systems or clicker software is not as widely spread as it is in other countries like e.g. the USA yet. Most clicker literature, however, only deals with implementing clicker systems in classes with up to a few hundred students. Therefore the technical process has been fostered and accompanied by researchers in didactics on the one hand and experts in information technology on the other. This interdisciplinary approach allowed for a multi-angle view on the implementation of the clicker software in anticipation of avoiding typical or common “beginner’s mistakes” beforehand.

2. Intended Goals
The initial and main goal of the implementation of ARS in the lecture was to give students the chance to actively take part in the lecture instead of taking in all the information as a rather passive consumer. This is especially important when teaching a programming language¹: just like with any other language you do not automatically learn by listening. It is the exercise that enhances the learning process. Another important goal as previously mentioned was to get an insight in the student learning and possible knowledge gaps. Based on immediate feedback made convenient by the use of modern technology it is possible to react near-term to difficulties in comprehension by repeating difficult subjects, starting a discussion about a controversial point or even changing the focus of the lecture. Rosenberg et al. point out further benefits of the implementation of ARS in class:

“Research has shown that students in courses using interactive engagement techniques (…) achieve a much greater gain in conceptual understanding than students in traditional

¹ The language taught in the described lecture is Java.
lecture courses while also improving their ability to solve quantitative problems.” [3]

Additionally, clicker questions are also known for their motivational benefits. „The questions are designed to motivate students and to unveil potential difficulties with the course topics and material.” [4] As a positive ‘side-effect’, ARS offer the opportunity to connect learning with fun. “This approach has two benefits: It continuously actively engages the minds of the students, and it provides frequent and continuous feedback (to both the students and the instructor) about the level of understanding of the subject being discussed.” [5]

3. Realization

While using ARS – especially hardware clickers – in class has been a common strategy for many years in countries like the USA, German universities have only discovered the benefits of these systems in the last few years. This means that the launch is expected to be ‘virgin soil’. The launch has been carefully planned and realized by an interdisciplinary group of researchers in engineering, information technology and didactics. In a first step, possible questions were sought that matched the aims in teaching and learning of the lecturer. When looking for the appropriate application type, several can be chosen from. Here are some examples of purposes for which ARS can be used:

- Multiple-choice questioning
- Asking for computational results (numbers)
- Asking for coordinates (mark a point)
- Asking for Feedback by Multiple Choice (positive/negative)
  - Asking for free text feedback
  - Asking to enter questions
  - Asking for free text answers
  - Sequencing, etc.

Multiple-choice questions again offer several options of application:

- Choice of a right statement/answer
- Choice of a wrong statement/answer
- Choice of the right computational result, etc.

When integrating clicker questions in the topics of the lecture, it has to be considered that they take up a certain amount of time (questioning, polling, discussion) of the lecture – approximately three to five minutes each. So it is highly important to carefully plan when and on which topic they can be applied reasonably. Given the information that previous test results of the lecture have shown that the topic with the highest failure rate was coding, the clicker questions in this particular case were designed specifically for the lectures covering this topic in order to detect difficulties in understanding early on.

Before using the software for the first serious clicker question, the lecturer shortly introduced the software during the lecture by a non-subject-related question. He also explained that the appearance of a question mark in the right hand corner of a slide signals a forthcoming question on one of the following slides. This element was chosen to keep the motivation and attention of the students at a high level. The first serious clicker questions were posed to keep track of the difficulties students might have when learning the basics of programming with Java. It was expected to be able to subsequently minimize these difficulties by discussing given answers. Figure 1 shows a screenshot of a clicker question slide and the response frequency in percent from the lecture.

In terms of the subject, the clicker question aims to check and foster the students’ basic apprehension of the effects of operators. The question demonstrates decreasing a number variable using the postfix operator for and problems arising from implicit typecasting. The slide shows a code. The question posed to the students is a multiple choice question of the right statement: “There is an error message while compiling, because…” The students can choose from four different answers that are supposed to detect the mistake in the code. While the majority (68%) of the students answers the question correctly, 32% give a wrong answer. With this result the lecturer can seize the opportunity to explain, why the other options are incorrect to eliminate future mistakes.

Figure 2 shows a slightly different result.
On the second question slide the students see another code. This time, the question serves the purpose of showing the effects of different mathematical operators. The question posed to the students is: "Which result does the command calculate(3,2) produce on the display?" The question thus asks for a choice of the right computational result. The answers to this question appear not to have a clear tendency as in Figure 1. This indicates that a majority of the students at this point of the lecture do not know the correct answer. This again gives the lecturer the opportunity to discuss and explain the answer. After the discussion and explanation a similar question but with a higher level of complexity is being posed to check possible learnings or difficulties of the students (Fig. 3).

Figure 3: Screenshot of a clicker question with a clear tendency towards a wrong answer

The third question following shortly after the second one is another question of choice of the right computational result. Here, the workflow of a switch statement is demonstrated. The special focus lies on its behavior to execute all subsequent commands once a case has been matched. The question posed to the students is: “Which result does the command calculate(4,11) produce on the display?” The results show that 64% of the students have chosen the wrong answer. Only 19% of the students have answered the question correctly. After the display of the result, a positive and estimated side-effect was being observed by the teaching staff: subject-related discussions among the students began to evolve and the students tried to figure out why answer number 2 was the correct one. After that, the lecturer explained again and subsequently went on with the lecture. The following chapter shows and analyzes the results of the first evaluation of the trial implementation of ‘poll everywhere’ in the lecture by the students.

4. Results of first evaluation

Worldwide evaluations at universities show that the application of ARS in lectures has led to e.g. higher motivation of attendance [6], more attention of the students during class and even higher knowledge acquisition than in conventional (non-interactive) classes. [7] After several trials the new ARS in the described setting was evaluated by the students near the end of the semester. The evaluation in this particular case was designed to cover the main topics motivation, usability and conceptual design of the questions. The evaluation on the RWTH Aachen University was carried out near the end of the semester, after several trials with the new ARS.

There are about 1800 ARS-related and filled-out evaluation sheets from the lecture. The questions posed were mostly closed-ended questions except for the comments section at the end. They can be divided into several sections which included questions concerning:

- participation,
- impact on comprehension and content,
- motivational aspects,
- rating of the software itself and the methodological launch in the lecture.

The following sections will provide an insight into the most significant results of the evaluation. Every student (with an exception of two) who took part in the evaluation attended the particular lectures in which clicker questions were being posed. 60.3% of the students actually used the software at least once to answer a question, 35% of them participated in every single poll. Most of the students (43.3%) used the software on their smartphone. 27.6% did not participate at all because they did not have a smartphone or notebook (with them) and they probably did not want to spend extra money by sending a text message.

Figure 4 shows results of the evaluation concerning aspects of subject-related comprehension and content. A vast majority of the students (93.6%) state that the questions were comprehensible and had a suitable complexity (81.1%). Around 63% say that the questions in class enhanced their comprehension which underlines the assumptions as drawn above: that posing adequate clicker questions and discussing right and wrong answers does not only activate students but can also foster and reveal their learning process. Nevertheless, a majority of 56.3% also state that the questions did not help preparing for assessment. An especially positive outcome is that 70.9% state that the questions enhance the quality of the lecture which leaves only 26.8% stating that they don’t.

Figure 4: Results of the evaluation concerning aspects of comprehension and content
Figure 5 shows the results concerning motivational aspects of the use of ARS in class. A majority (80,1%) of the students enjoyed participating in polls. As has previously been found in other research, the clicker questions motivated a majority (79,7%) of the students to be more attentive during the lecture. Only for 29% of the students, however, see clicker questions as a motivating element for students to attend to the lecture at all. 68,7% feel motivated to participate in the discussion of the subject and a similar number (69,6%) state that ARS help feeling more involved in the lecture. A total of 72,8% even wish for more clicker questions throughout the semester.

Facility of Participation

The evaluation shows that the main reason for the relatively small number of participants can be ascribed to the weak WiFi connection. This problem can only be solved by the university. In order to avoid the frustration of not being able to participate, it is therefore highly important to address this problem to responsible university staff and give them the chance to improve the conditions.

The problem of participation without an own smartphone or laptop can be solved by having students team up in groups of up to a maximum of five students, each group having at least one functioning device to participate.

One decisive element regarding the software ‘poll everywhere’ is often underestimated by software designers: the integration of polls in the slides of the lecture – in this case power point slides. This feature allows for the lecturer to avoid discontinuities during the lecture and consequently avoids non-subject-related actions or breaks and the students could be distracted by. A change of the user interface, e.g., takes up time that students will most likely use to chat – and gaining back the attention of 2000 students once one has lost it can be very challenging. It is therefore recommended to choose software that provides the feature outlined above.

Methodology

The solution to the described criticism towards real-time tracking of the polls problem can be a simple one. The software allows for both methods of poll tracking – hidden as well as visible. Both methods have been tested in the trial. Both ways are plausible when linked to specific didactical goals. It is recommended to hide the development of the poll until an acceptable number of answers have been registered, close the poll and show the answers afterwards, unless a specific learning goal is being pursued. Showing the development of a poll in real time, however, can also be useful when e.g. linked to a certain didactical strategy such as peer instruction.

As has been previously stated, the sole implementation of an ARS in class cannot generate an improvement of a lecture – ideally, there is a didactical or conceptual goal behind every single question. Therefore, another suggestion is to combine clicker questions with successful didactical concepts such as just-in-time (JIT) teaching methods or e.g. peer instruction (PI).

“Just-in-Time Teaching (JiTT) is an ideal complement to PI, as JiTT structures students' reading before class and provides feedback so the instructor can tailor the PI questions to target student difficulties.” (Watkins/Mazur) [9]

“When PI is used, students are first asked to answer a question individually, and then a histogram of their responses may be displayed to the class. If there is substantial disagreement among responses, students are invited to discuss questions briefly with their neighbors and then revote before the correct answer is revealed. The instructor then displays the

Figure 5: Results of the evaluation concerning motivational aspects

Adjacent to the predominance of positive responses there also were some points of criticism. Most of these were related to the technical implementation given that the WiFi connection did not work well as soon as a lot of students wanted to participate at the same time. This explains why only a relatively small number of students participated in the polls with numbers around approximately 25% of the students in the lecture per poll. Although most of the students thought dealing with the software itself was simple (84,4%), some of them wished for a slightly longer answering period. Other students criticized real time tracking of the polls which has been used for some of the polls as they felt influenced by the already given answers of the other students.

In the comment section of the evaluation ten students specifically complimented the use of ARS. In addition to that there were also suggestions in which part of the lecture clicker questions should be used. Four students said that it would be better if clicker questions were used at the end of the lecture or at the end of a topic. Six students criticized that it was not possible for them to take part, because they had no smartphone or other device to participate.

5. Adjustments and Recommendations

The analysis of the evaluation has shown that most of the anticipated benefits of ARS [8] also apply when dealing with XL classes. Nevertheless, there was also criticism towards some important aspects such as the facility of participation – weak WiFi connection/lack of devices – and the methodology itself – presentation of poll results, frequency of questions, point of time etc. This criticism allows for several recommendations for future use adjustments to be made. The most preeminent points of criticism will here be discussed in terms of possible solutions. The largely positive reaction, however, allows for a recommendation of broadening of the use of ARS in very large classes.
new histogram and explains the reasoning behind the correct answer.” (Smith et al.) [10]

In the first ARS-trial of the described lecture solely multiple-choice questions were applied in order to check the apprehension of previously explained methods of e.g. programming or else explain it again. As Crouch et al. state there is, however, a possibility to use open ended questions in lectures with a lot of students:

“In a course with a large enrollment, it is often easiest for the instructor to poll for answers to multiple-choice questions. However, open-ended questions can also be posed using a variety of strategies. For example, the instructor can pose a question and ask students to write their answers in their notebooks. After giving students time to answer, the instructor lists several answer choices and asks students to select the choice that most closely corresponds to their own. Answer choices can be prepared ahead of time, or the instructor can identify common student answers by walking around the room while students are recording their answers and prepare a list in real time.” (Crouch et al.) [11]

Crouch et al. hereby describe one of unlimited options to pose open ended questions. This approach allows for a mix of approved didactical methods with new technology. Technology itself does not replace didactics or in Beatthy’s words: “Technology doesn’t inherently improve learning” [12]. Only when choosing the ‘right’ strategy can a learning goal be achieved.

6. Future Prospects and research fields

The evaluation shows that using clicker software can be an efficient means to engage students – also in a very large class. Students in this particular class found the educational software to be motivating in terms of participation in class and helpful towards understanding. Nevertheless it is not a magic tool that automatically enhances motivation and learning. One result towards learning is that almost half of the students taking part in the evaluation somewhat agree that the questions in the lecture enhanced comprehension of the proposed subject, but did not specifically help when preparing for assessment. There was also the problem of participation – partly students were unable to participate in polls because they either did not own or bring a necessary device such as a phone or a laptop or the weak WiFi-connection did not allow for participation. It will therefore be a task for the second trial to on the one hand give the university the chance to improve the WiFi-connection while on the other to adapt methods that allow e.g. group participation to make sure every student can be involved. Many students wished for more clicker questions throughout the semester. As in the trial clicker questions were only posed in a few of the lectures, there is still latitude for extension.

The second trial shows the advantage of having more time – now that the technical implementation has been completed – to focus even more on subject-specific aspect of the clicker questions. One of the future prospects in the ‘big picture’ will furthermore be to use results of clicker questions in order to consequently detect knowledge gaps at an early stage. In terms of a holistic approach, the next step will then be to concurrently adapt the supplementary courses and exercises by focusing on these specific most challenging topics and most certainly to subsequently conduct further evaluations

9. References


