2Q-System: A Tool for Lesson Planning and Continuous Monitoring of In-Lesson Learning Progress

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Abstract. We developed a system based on a series of two multiple-choice questions (2Q-system) used for diagnostics of students knowledge at the beginning of physics exercise classes and to continuously monitor the learning progress during the course. The system was successfully implemented at ETH Zurich for selected introductory and advanced physics courses. With the 2Q-system we were able to measure learning gains of more than 25 % in almost all lessons.

1 2Q-system: motivation and method

Formative assessment (FA) tools are generally accepted to improve the learning success of students in classroom settings. If combined with diagnostic tools the learning process can even be time resolved [1]. Typically, FA and diagnostics are separate teaching tools as they serve different purposes. It is encouraged to perform FA on a regular basis. However, especially in university settings where the teaching time is limited, not every lesson can include a substantial learning diagnostics session.

We present here a tool, which combines FA elements, and diagnostics in the format of two specially designed pre- and post-lesson multiple-response questions (2Q-system). The questions are based on key learning objectives of the lesson and aim to probe higher-level competences of the students. The answers to the pre-lesson questions are not revealed and at the end of the lesson the same two questions are asked again, this time with subsequent discussion of the answers. In total, this format takes no more than 5 minutes from the lesson time.

In principle, students should be able to answer the questions directly after the lecture and before the exercise class starts. However, often students struggle to get deep understanding of the topic during the lecture and are not able to apply their knowledge without practical exercise [2].

In this context, we developed a tool that allows to monitor student's learning progress, but at the same time acts also as engaging learning activity and can give students a sense of self-efficacy when seeing their learning progress [3].

Namely, the 2Q-system allowed to complete the following purposes:

- To assess students' state of knowledge directly after the lecture.
- To continuously monitor student's progress during each lesson.
- To engage and motivate students from the very first minute of the lesson.
- To guide TAs in the lesson preparation workflow.

2 Context

We employed the 2Q-system while teaching introductory physics as well as advanced nuclear and particle physics at ETH Zürich in spring semester 2021 and fall semester 2021. The courses are organized as a main lecture held by the professor in a lecture hall with > 300 students and supported by weekly exercise classes with groups of < 20 students. Each exercise class is taught by a teaching assistant (TA), typically a PhD or undergraduate student. The exercise classes are meant to help students review the lecture topics and to enable them to solve challenging homework assignments. We defined learning objectives for each exercise lesson and developed the didactical materials and activities for the TAs to meet these objectives. Each of the lessons started and ended with 2Q-system questions targeted at the learning objectives. In addition, we developed further learning activities including elements of summary slides/advance organizers, multiple choice questions and problems similar to the end-of-term exam. All our materials were shared among the TAs and compiled in an E-book format [4].

3 Results

As expected, the number of correct answers was low in the pre-lesson questions. This shows that the learning effect of the lecture was not very high. However, on average the number of correct answers increased by about 25 % at the end of each lesson when the questions were asked again. When asked, students consistently said that the 2Q-system was the key to an engaging lesson, as it provided an immediate motivation to deal with the subject matter of the lesson.

4 Conclusion

We sucessfully tested a simple 2Q-system in exercise classes on introductory physics and on nuclear and particle physics. All the didactical materials are available in form of eBook editions. The system allowed us to track the student's learning process during every lesson. On average the number of correct answers improved by 25 % and students felt strongly engaged and motivated by this format. Implementation and data taking is simple so we plan to increase the number of students taught with this system and expand it to a larger variety of physics courses at university level. The system can also be applied at high-school level.

References

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