Multiple-Choice Questions for Testing Understanding in Higher Mathematics

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Abstract:

In an educational project in the lecture course "Höhere Mathematik A für Elektrotechniker" (Higher Mathematics A for Electrical Engineers) understanding and logical reasoning are tested with an innovative kind of multiple-choice questions. The questions offer each five options of which exactly one must be selected, and they test knowledge, problem solving and understanding. The majority of the multiple-choice questions are in the "Online-Lernerfolgstests" (online tests for learning success), but some questions are presented on the weekly exercise sheets, and solutions to these questions can be submitted for (manual) marking. For the questions on the weekly exercise sheets, a proper mathematical analysis of the selected option must be given to get full marks.

Good multiple-choice questions that test understanding of higher mathematics are not easy to design. The questions developed in this project go in a similar direction as the examples of multiple-choice questions reported by Kamps & van Lint (1975, in particular items H and J of their multiple-choice test) and Huntley, Engelbrecht & Harding (2009). Variants of similar types of multiple-choice questions appear to have been used in written mathematical examinations at some German universities. Schmidt, Macht & Hess (2005) provide a collection of mathematical multiple-choice questions with detailed answers (from previous mathematics examinations for economics students) that are of similar types to those developed by the author. However, the average level of the questions in Schmidt, Macht & Hess (2005) is lower, and they do not cover all the types of multiple-choice questions developed in my project.

In the first part of my talk, I will explain the motivation and the educational background for the project and present the theoretical background using a taxonomy for learning, teaching and assessing. This taxonomy is not the widely used taxonomy by Anderson & Krathwohl (2001), based on Bloom's taxonomy (see Bloom (1956)), but a mathematical taxonomy developed by Smith et al. (1996) for the purpose of classifying exercises and exam questions. This taxonomy has been slightly modified (seen also Huntley (2008)), and a second dimension for measuring the level of difficulty has been added. The modified taxonomy is used to map the direct learning outcomes of the course and to classify the multiple choice questions developed in the project.

In the second part of my talk, I will present several multiple-choice questions from the project and show some explanations given by students to justify their chosen option among the five possible answers. The students' explanations will illustrate several misconceptions about individual topics among the course material.

The project has transfer potential in several directions. On the one hand, multiple choice questions for testing knowledge, understanding and critical thinking can be used in other "MINT" (STEM) subjects, but it seems even possible to set such questions in entirely different subjects outside the "MINT" (STEM) area. On the other hand, such questions offer much potential for e-assessment, which is currently of great interest in order to cope with assessing large numbers of students efficiently (e.g. in economics or in some engineering disciplines) and also in order to offer "assessment on demand".

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