Short Report on the Discussion Group Results at the 16th SEFI MWG Seminar in Salamanca, Spain, June 28-30, 2012

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Discussion 1:

How could the competency approach be helpful in guiding mathematics educators?

As an introduction to the discussion the main terms were recalled, that is the definition of mathematical competence and a description of the eight mathematical competencies as identified in the Danish KOM project. There, mathematical competence was defined as "the ability to understand, judge, do and use mathematics in a variety of intra- and extra-mathematical contexts and situations in which mathematics plays or could play a role". Mathematical competence can be split up into eight overlapping competencies which are: Mathematical thinking and reasoning, mathematical problem solving and modeling, dealing with mathematical representations and handling symbols and formalism, mathematical communication and using aids and tools.

In the group discussions, participants saw advantages and risks of the competency approach as well as necessary further developments in the future. The definition of competency was seen as very comprehensive carrying a lot of meanings. The eight competencies are helpful for thinking about the goals of the mathematical education of engineers as well as for making explicit to engineering students what the mathematical education is good for. They can be used to create educator as well as student awareness of educational goals. In order to be more useful the eight competencies must be made more specific for study courses in engineering. There won't be a "one-fits-all-curriculum" for all students in all study courses and there is no binary situation in which a person is or is not mathematically competent. The mathematical competence of an engineer will be different from the mathematical competence of a mathematician. So, profiles have to be identified and a clearer description of what a student should be able to do to show that (s)he has acquired a certain competency to a certain extent must be given. This is also related to the question raised in the discussion how competencies and learning outcomes fit together and how one can measure competency. The risk that was seen by some participants is that the concept might end up in a bureaucratic misuse where the competencies are used without further specification as "anemic" set of vague, high-level concepts (e.g. for accreditation purposes). Instead, a set of "best practice" examples would be helpful to provide good orientation for those who see potential in the concept.

The competency concept specifically addresses the use of mathematics in intra- and extra-mathematical contexts and situations. The issue was raised how volatile these contexts and situations are and who has a stake in these. There are employers' needs and societal needs, and mathematics has also a structure of its own. Since needs change, so might the education addressing different contexts and situations.

Discussion 2:

What learning and assessment scenarios are suitable for competence-oriented mathematical education of engineers?

The keynote lecture by C.-H. Fant on "Aligned Assessment" and talks on suitable learning and assessment scenarios for acquiring mathematical competence served as input to the second discussion.

Regarding the learning of mathematical competencies it was widely agreed that a mixture of different learning scenarios is called for. Moreover, not in every course is each of the eight competencies equally considered; competence develops over time and over all courses covering the mathematical education of engineers and beyond. Modules later on in the student career trying to synthesize the ideas learnt so far might also be helpful in this respect. It was emphasized by some participants that mathematics and the application of mathematics should be learned simultaneously and not in sequence.

Lectures were seen as still having potential for competence acquisition and they are still important since they are in wide use in order to address a larger number of students. It depends very much on the didactical qualifications of the lecturer and the attitude and willingness of the student whether lectures are a successful means of competence acquisition. Group size is important and means of student activation like voting systems provide additional potential. Group work was considered as a suitable means to foster mathematical thinking and reasoning. As another means to improve the reasoning competency it was stated that students could be asked whether a certain statement is true or false, and could then be requested to explain their decision. Regarding the problem solving competency student could be asked to identify problems on their own.

The necessity of aligning assessment and educational goals was strongly supported since most students are extremely assessment-driven. So, in a competency-based curriculum it should be kept in mind that all competencies should also be assessed. That probably cannot be done in isolation since the competencies overlap and are strongly connected. The assessment should not just be summative at the end but also formative continuously (as when acquiring the driver's license). Competencies cannot be fully assessed just by short term exams. In addition to written exams, assessment arrangements like project defenses or oral exams are also important for a more comprehensive coverage. Assessing competencies raises the problem of how competence acquisition can be measured. For this, the intended level of competencies must be specified in more detail by identifying aspects of a competency to be acquired. For the modeling competency this could be the aspect of setting up models and for the reasoning competency the ability to follow logical arguments given by others. Again, a collection of best practice example would be very helpful. It should be avoided that competencies degenerate to mere "tick-boxes" on a check list as is sometimes the case in school education when teachers are evaluated.