Discussion on „Which mathematical modelling competencies are important for engineers and how should they be taught?"

Burkhard Alpers, Aalen University of Applied Sciences; July 2010

The discussion was preceded by the keynote talk by Gabriele Kaiser (University of Hamburg) on "Mathematical modeling competencies: meaning, teaching and assessment". She explained the competencies required for mathematical modeling by going through the different steps in the modeling cycle (setting up a real world model, translating this into a mathematical model, solving the problem in the mathematical model, interpreting the results in real world terms and validating the model). She emphasized that teaching of modeling comprises on the one hand the "atomistic" view of teaching single competencies in the cycle but on the other hand also the "holistic" view of going through the whole cycle. The holistic view also requires meta-cognitive competencies regarding to monitoring one's own procedure through the cycle and deciding on how to go back and forth.

In the group discussions it was recognized that modeling competencies are quite important for engineers. It is necessary for engineers to understand the problems of customers by sort of turning a problem situation into a real model. For this, problems have to be simplified. Recognition of central variables, formulation of assumptions, selection of a mathematical model, work within this model and interpretation of results are then essential steps. Engineers should be critical about the results of their mathematical calculations using tools, i.e. being able to validate results is very important. It was also emphasized that engineers should have a "sense of direction" in their work, i.e. they should monitor their own procedures in order to see whether they lead to the desired goals and make modifications if required. They also have to write down and support their arguments for getting to the suggested solution (simplifications, choice of model etc.). This can be considered as a meta-cognitive competency. Moreover, for recognizing the possibilities mathematics has to offer for a solution of a problem and for choosing suitable mathematical models, a sound mathematical knowledge base is inevitable. It would be helpful to have "model building blocks" for decomposing and/or recomposing models.

Regarding teaching mathematical modeling, several contributors to the discussions thought that this should be integrated in the normal mathematical education of engineers, possibly in cooperation with engineers teaching application subjects. One could start with existing models and formulate open questions within these models. As an incentive for working on such problems, students could be given "bonus points" for the final examination. Modeling problems could also be included in the normal examination in order to make work on such problems obligatory. It was also mentioned that using a mathematical concept as a model for different application situations is often already included in normal math teaching; e.g., setting up a differential equation for a damped spring-mass-system or for an electrical circuit and solving application problems using this model. This way, it is also possible to show the power of mathematics which provides common models for quite different application situations.

It was also discussed that spending more time on modeling might lead to a reduced time for covering the "usual" content and training of calculation skills. Since there is much complaint about poor calculation skills of students entering university, there is also the fear that this bad situation might be continued at university by cutting back time for training.