

Innovative Methods in Engineering Education

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Summary

The need in well trained engineers is very huge. At present, the enterprises cannot fill all job openings. Therefore, the number of graduates has to be increased. A high dropout rate is a current problem in the engineer's sciences. The tertiary institutions have to reduce the numbers of dropouts and have to raise the student success. The government must support the tertiary institutions for the realisation of these aims, for example with an "initiative of excellence for teaching".

Abstract

To protect the future of Germany as a center of high technology as well as as a business and industrial location in the long run, we have to counteract the imminent shortage of engineers. The Bologna process with its Bachelor and Master degree programs replaces the traditional German degree courses. This academic reform provides tertiary institutions with additional chances to increase the attractiveness of their study programs and thus to increase the number of graduates.

Challenges for tertiary institutions

As a result, tertiary institutions have to meet a number of challenges. Especially with regard to the further development and quality of teaching, innovative teaching and learning methods enable students to obtain social and personal skills as well as professional and methodological competencies. In doing so, problem- and project-based learning illustrates practical relevance.

Increased diversity of students' levels and skills poses another challenge. In response, tertiary institutions offer a great variety of services such as introductory phases, consultation services, support and mentoring programs, part-time studies, modules designed to be achievable while working (so called block-release courses), and opportunities for the recognition of previously acquired competencies.

A rise in the number of students has adversely affected the learning atmosphere. Finding solutions for this fact is another challenge for tertiary institutions. There is a great demand for teaching staff as well in order to achieve a better student/lecturer ratio. Therefore, tertiary institutions need more operating funds for teaching staff (VDI 2011).

Demands on tertiary institutions

The attractiveness of degree courses and their success rate has to increase. Contents and demands in the curricula are supposed to be built upon on each other. The subject matter and didactics of each course must be clearly expressed in the module handbook. In addition,

the courses have to be designed according to the time they should be completed in successfully.

The Universities of Applied Sciences strive to fit their educational training according to the demands of working practice. The differences between the Universities of Applied Sciences (learning by example) and the Universities (learning through research) have to remain. With these two educational training options, we train talents with the individual qualifications HR Managers are searching for (VDI 2011).

Demands on federal states

A reputable professor is someone who is doing excellent research, but also someone with excellent didactical skills. In order to improve the learning atmosphere, the lecturers need to make use of several teaching techniques. Therefore, it is necessary to found superregional Lecturer Training Centers. One motivation to use different teaching methods could be awards for teaching staff. Capacities should be planned according to a structure that actually rewards innovative teaching and learning methods, because this can positively affect the application of these didactical methods. To establish this aspect in the higher education act is in the federal states' remit (VDI 2011).

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Some prerequisites must be given for teaching using innovative methods in engineering education:

- Qualified lecturers
- Qualified graduate teaching assistants
- Adequate technical equipment and facilities
- Scheduling of the lectures given by curriculum

(Bunting et al 2011; Johri and Olds 2011; VDI 2011)

Countless different methods can be used. For example:

live-demos, readings and discussions of state-of-the-art literature, presentations, academic research, guest lecturers, case studies seminars, intensive courses, discussion groups, field trips, lab lectures, expert interviews, mentoring, tutorial teaching, world Café, expectation queries, flashlight, partner-conversation, teamwork, fishbowl, group puzzles, expert groups, open-space, walt-disney-method, six-thinking-hats, brainstorming, mindmapping, etc.

Project-based learning integrates these methods. For project-based learning, methods can be selected individually according to each learning situation and education target. As an example, this didactic method will be explained.

It is taught on the basis of current issues and practical-related tasks. Students receive a curriculum-based project which could have several solutions. The problem is often of interdisciplinary nature (Ricken et al. 2009). The presented problem has to be a realistic one so that the students show a certain interest in the topic. Learning in a sustained manner is only possible if students have a self-reliant learning-process. It is necessary that the lecturers provide suitable teaching and learning conditions. So that continuing academic education and social learning are possible (Chandrasekaran et al. 2012).

Students work in groups to identify what they need to learn in order to solve a problem. A work-related problem for which they develop a solution path by themselves and which they work on with the option of consultation, but often independently. In limited time they have to develop a result which is then documented and is presented. The exam requirements rise every semester (Hmelo-Silver 2004). If the process and the results are accompanied by

reflection and feedback, students may develop interpersonal competences. Interpersonal competences are important for many areas of professional practice (VDI 2011)

Project-based learning is a didactic method. Using this method, students benefit of the diversity of a group, and they can bring in individual abilities. Students learn to work on their individual skills regarding critical thinking and problem solving, creativity and innovation, collaboration/teamwork and leadership, cross-cultural understanding, communications and information fluency, career and learning self-reliance and project management (Eder et al 2011; Linke 2012; Moylan 2008). They recognize that their learning success advances when they show self-initiative, motivation and the willingness to act as part of a team. For the learning process it is important to get individual feedback and that the students reflect themselves and the learning process as a whole (Hadgraft et al 2003).

Project-based learning can be used in single sequences (a combination of lecture and project-based learning) or as the predominant teaching method in a module. As a result, the forms of assessment have to be chosen. Accordingly, the assessment has to consider both the result and the working process. Adequate examination requirements for individual marking are practical tests of the result/product, presentations with discussions and seminar papers of the working process and the result/product (Brinker 2012).

Conclusion

It is still a huge challenge to realise innovative methods in curricula. Innovative methods in engineering education combine theory, academic methods and professional practice. Using innovative didactic concepts in education is an excellent method to prepare students for the labor market. Therefore, the reorganisation of the curricula and the continuing didactical education of the lecturers are necessary. In addition to research, teaching must take a central focus in tertiary institutions. As a result, more operating funds are needed. Operating funds should be planned according to a structure that actually rewards success in teaching. Furthermore, research projects in engineering education have to be promoted. The government needs to support the tertiary institutions for the realization of these aims, for example through an "initiative of excellence for teaching". It takes time and money to convince the stakeholders that innovation in teaching and learning methods is of the essence and that we must actively pursue it.

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