CHALLENGES OF LARGE GROUP STUDY COURSES IN ENGINEERING EDUCATION

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ABSTRACT

Teaching in front of large audiences (>700 students) is a challenge to every lecturer. Because of the rising shortage of skilled workers particularly in engineering education new ways to provide high-quality education while at the same time allowing for large audiences need to be designed. An essential way to improve engineering education is seen in the "shift from teaching to learning", i. e. from teacher-centered to student-centered education. A possible strategy of student-centered learning is "project-based learning" which facilitates action-oriented and sustainable learning. Although it is a big challenge, project-based learning can also be successfully used in large group study courses.

Besides a description of central challenges when dealing with large audiences the article points out the importance of didactically innovative and student-centered forms of teaching and learning for engineering education. Furthermore, the article sketches project-based learning as a form of student-centered learning and gives a case study of the course "Communication and Organizational Development" at RWTH Aachen University.

CHALLENGES OF LARGE GROUP STUDY COURSES IN ENGINEERING EDUCATION

1 INTRODUCTION

With continuously increasing numbers of students and at the same time shrinking funds, lecturers are confronted with large audiences (>700 students) more than ever before. How can the subject matter of mass events be conveyed to the individual student and be understandable for everyone? What forms of interaction are appropriate? How does the subject matter catch on with the individual students? These are some of the questions that teachers of a huge audience have to find answers to.

Since more than one decade the notion "shift from teaching to learning" (cf. Barr/Tagg 1995) has been used for expressing the change from a teacher-centered to a student-centered view of learning. This paper presents the shift from teaching to learning and its central characteristics. Constitutive challenges of teaching large group study courses as well as the particular situation in engineering education are described, especially shadowed against the background of student-centered learning. In lectures with high numbers of students the application of active and student-centered learning is demanding and goes along with new responsibilities for lecturers. Especially in engineering education, the situation of large audiences is made worse by the shortage of skilled workers caused by demographic factors. Therefore it is a decisive factor to reduce the quota of university drop-outs in engineering science and to improve the quality of teaching.

Furthermore, this paper presents project-based learning as one possible strategy of student-centered learning. Project-based learning starts out from a problem that students have to solve on their own through team work. This course of action fosters both professional and supra-professional skills. Finally, the course "Communication and Organizational Development" at RWTH University is presented as one example of employing project-based learning in engineering education with large audiences. In a lecture-complementary practice session some 1200 students pass through a process of organizational development where they team up to found a fictional automotive enterprise and build the prototype of an innovative automobile.

2 SHIFT FROM TEACHING TO LEARNING

In the course of the Bologna Process that was started in 1999 by 30 European states a paradigm change in teaching and studying has been initiated for the European university landscape. One central idea of the paradigm change is to entirely rethink university teaching from the perspective of student learning (cf. Barr/Tagg 1995). Affected by the 1995 article of Robert B. Barr and John Tagg "Shift from Teaching to Learning – A New Paradigm for Undergraduate Education", the expression "from teaching to learning" has become the leading motif of a new quality of studying and learning that stands for a new view on teaching (cf. Wildt/Eberhardt 2010: 15f.).

From the viewpoint of university didactics the shift "from teaching to learning" is about replacing the traditional, rather presentational and instructional paradigm of university teaching by a notion of teaching that understands itself as fostering of student learning.

Besides the basic change of perspective that tries to design teaching from the student viewpoint this approach encompasses the requirement that students carry a central responsibility within the learning process (cf. Wildt 2003: 16). The shift from teaching to learning looks at the learning results and at the strategies used to reach them (cf. Wildt 2005: 6).

One major prerequisite for the success of student-centered learning is that the teachers attend the learning process as a coach (cf. Barr/Tagg1995: 707f.). Learning processes can be described as a triangle relationship between teachers, students and the topic. In didactic theoretical tradition this is depicted by the didactic triangle according to Heger (2005) (cf. Fig.1). Thereby, the triangle relationship can be designed in a variety of ways. Hitherto existing university teaching is often still affected by a classic role constellation expressed e. g. in lecturing (cf. Wildt/Eberhardt 2010: 17): the teachers are tasked with processing content, they fabricate knowledge and transport it to the learners, as pointed out by the two broken lines starting from content via the teacher to the learner (cf. Fig.1). In the student-centered notion of university teaching, however, the learner stands in direct interaction with the content while the teacher helps to organize this process. Fig. 1 depicts this with the continuous lines.

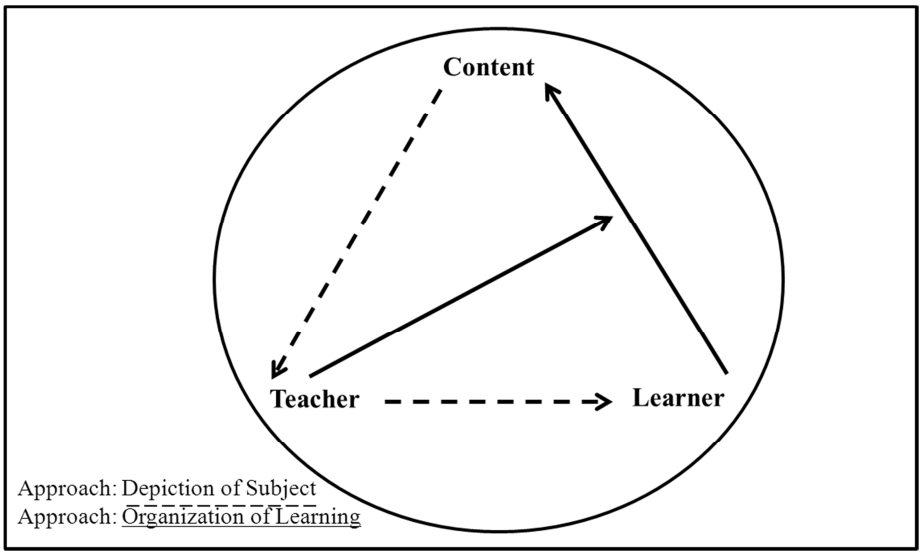

Figure 1: Didactic triangle (cf. Schröder 2010: 65f, according to Heger 2005: 158)

Barr and Tagg (1995) expressed the change from a teacher-centered to a student-centered view as a move from the “Instruction Paradigm” in which teachers deliver instructions to transfer knowledge from faculty to student to a “Learning Paradigm” in which universities produce learning (cf. Froyd/Simpson 2008: 1). According to that the shift from teaching to learning contains a change of roles of the teachers from their tasks of presentation and instruction via the construction of learning environments to accompaniment of learning where they aid and counsel students (cf. Fig. 2).

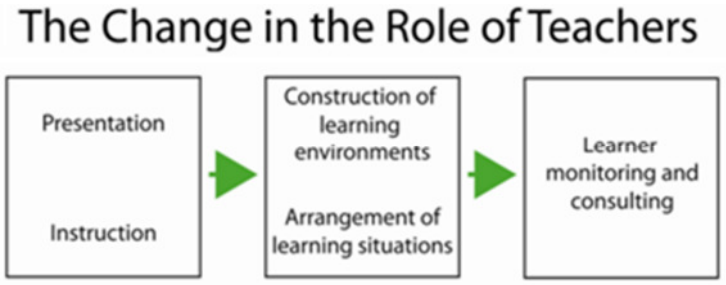

Figure 2: Change in the Role of Teachers according to Wildt (2005)

According to Wildt (2003) the change of view from teaching to learning can finally be described by the following characteristics:

- student-centered approach,
- change of the role of teacher away from the orientation towards instruction,
- orientation of learning towards goals and results,
- fostering of self-organized and active learning,
- consideration of motivational and social aspects of learning,
- linking of knowledge acquisition and acquisition of learning strategies.

With the shift from teaching to learning teaching is elaborated from the viewpoint of the student and the central role of the teacher is to enable a learning environment where students can actively develop their knowledge instead of having it conveyed only passively.

3 TEACHING LARGE GROUP STUDY COURSES

3.1 CENTRAL CHALLENGES

With the rising number of high school graduates university courses with large group study courses are not unusual. With constantly shrinking funds, a lot of lecturers have to face larger classes in order to make up for the lack of faculty members with regard to the growing number of students (cf. www.uwo.ca). Particularly in mass fields of study courses can have 700 to over 1000 participants (cf. Mayrberger/Schulmeister 2009).

The leader among the applied forms of university courses to address large numbers of students is the head-on tuition, i. e. the classical lecture. But the effort of teaching large classes by lecturing has not to be underestimated. Both lecturers as well as students face a number of physical and psychological problems that have to be solved. Thus, it is not enough for a professor to just talk louder, write bigger and make larger gestures. While lecturing, teachers stand in front of an undifferentiated mass and often cannot even recognize faces in the back of the room. Students on the other side feel faceless and suffer from anonymity.

Traditional lectures are hardly adequate to allow for an active learning of the students. In such forms of teaching there is less contact between the lecturer and the students, which gives fewer chances for feedback (cf. Schumacher 2003: 3). In the context of a mere listener, the student has a passive role and receives the information transmitted from the lecturer.

Nevertheless, against the clear disadvantages of large group lectures, because of the rising number of students, they will be inevitable in the future. For improving the study situation, it is rather about generating an expansion of the didactic action repertoire where the teachers create new learning environments that can be used to supplement lectures (cf. Wildt 2005: 2).

3.2 THE SITUATION IN ENGINEERING EDUCATION

93% of the lecturers in mechanical and electrical engineering bachelor degree programs state that they use the classical lecture format (cf. Fischer/Minsk 2008: 81). A dependable instrument to investigate how students cope with a given study situation and large classes is the dropout rate. A study from the Higher Education Information System (HIS) gives information about the dropout rates of different subject groups and the motives students stated when breaking off their studies (cf. Heublein et al. 2010). It shows that of all the students who enrolled in engineering sciences between 1999 and 2001, 25% left university without a degree. With 25% the most crucial reason for students breaking off studying in 2008 is their problem to perform services, followed by the lack of motivation to study with 20% (cf. Fig. 3).

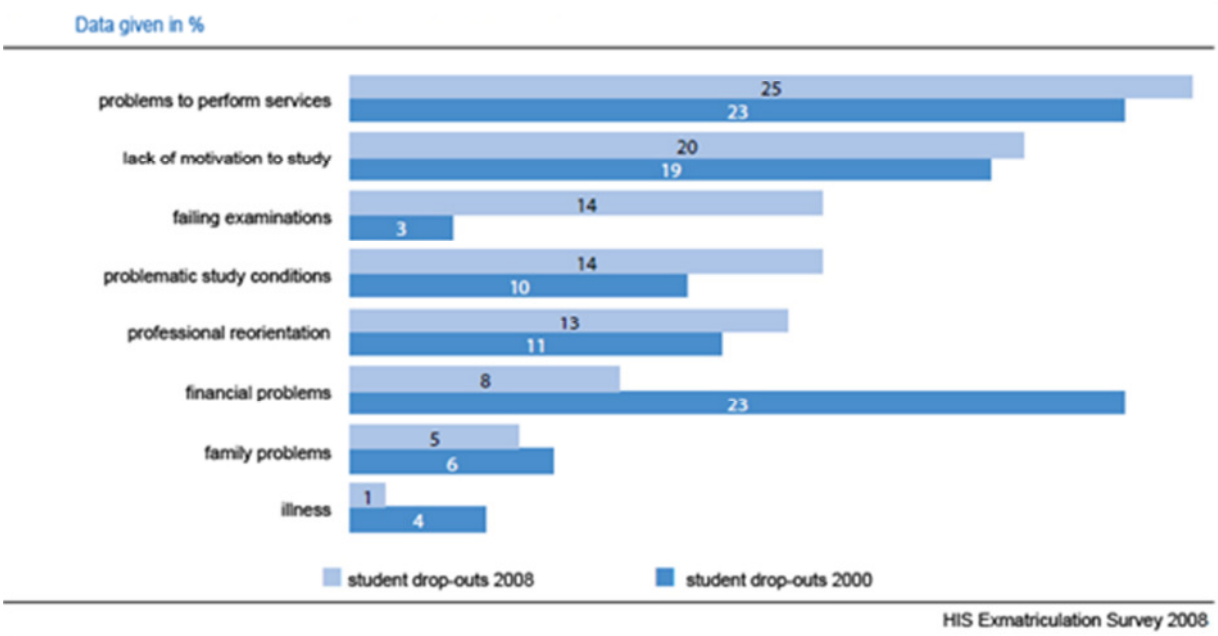

Figure 3: Crucial Dropout Reasons: Subject Group Engineering at Universities (Heublein et al. 2010: 20)

As the study shows, also failing in examinations (14%), problematic study conditions (14%) as well as professional reorientation (13%) are mentioned as central reasons for breaking off. As deficient study situation criteria the HIS study (cf. ibid.: 18) refers to

- confusing courses of study,
- overcrowded courses,
- lack of relevance and practice,
- insufficient study organization,
- lack of professional standards for the courses,
- lack of mentoring by lecturers,

- anonymity at the university,
- scarce university equipment.

Concerning the professional reorientation students declare the wish for a more practical education as the main reason for breaking off (cf. ibid.: 39). Their expectations of studying engineering science were not fulfilled as they probably were not informed enough when choosing the field of study.

Given the global lack of competent professional engineers, the number of engineering students leaving university without a degree is alarming. According to the outlook of the Cologne Institute for Economic Research (IW) in cooperation with The Association of German Engineers (VDI) there are not enough young graduates to replace the engineers who retire. By the year 2014 the German economy will eventually lack around 220.000 engineers, scientists and technicians whereas only an average of 37.000 engineers graduate each year (cf. Kloepfer/Sonnet 2010). Therefore, the high dropout quote in engineering studies must be cut and as many students as possible must be qualitatively educated at the same time.

The research of approaches that enhance teaching and learning under the condition of large audiences is a substantial task of the competence center for engineering education TeachING-LearnING.EU. As a cooperative project of RWTH Aachen University, the Ruhr University Bochum and the Technical University Dortmund, TeachING-LearnING.EU pursues the goal of sustainably improving the quality of engineering degree programs in the context of the Bologna Process. Project research has displayed that one successful teaching method for student-centered learning is project-based learning.

4 PROJECT-BASED LEARNING

Till today, many different approaches have been developed to teaching that fit the criteria for student-centered learning. One effective form of student-centered learning is project-based learning. In project-based learning students are confronted with a complex project that has to be collaboratively accomplished based on the learnt theoretical knowledge. While instructors or tutors take on the role as coaches and facilitators of learning, the learners are self-responsible for the most part of their activity and encouraged to take responsibility for their group and mission. In project-based learning the learning activities are organized around achieving a shared goal by project work. The instructor of project-based learning mediates specifications to reach the goal of the project and with the role as a facilitator controls the compliance with the correct proceeding (cf. Savery 2006: 16).

As Savery (2006) merges, learners are likely to encounter several problems by working on their project. At this, feedback and reflection on the learning process and group dynamics are essential components: periodical group-feedbacks in connection with working-units help learners to reflect their functioning and appreciate the outcome. The different teaching methods are adapted to respective learning targets, learner knowledge and context of the project as well as practical application, so that learners are able to memorize experiences that will serve them in future situations (cf. ibid.).

Project-based learning is a distinguished example for student-centered and active learning and advances effectively the acquirement of professional skills and abilities. Moylan (2008) identifies the skills that students learn with project-based learning as

- critical thinking and problem solving,
- creativity and innovation,
- collaboration, teamwork, and leadership,
- cross-cultural understanding,
- communications and information fluency,
- computing and information & communication technology fluency,
- career and learning self-reliance. (cf. Moylan 2008: 1)

For this reason, since the 1970s project-based learning continues to grow in popularity worldwide and is getting more and more common in engineering education, too. Although lecture-supplementary study courses and project-based learning are not a new occurrence in university teaching, they are still a central challenge especially for courses with large audiences. Despite of the didactical and organizational challenges the course "Communication and Organizational Development" at the RWTH Aachen University illustrates the implementation of project-based learning in a large group study course.

5 PROJECT-BASED LEARNING IN ENGINEERING EDUCATION

One example of dealing with large audiences by project-based learning is the course "Communication and Organizational Development" at RWTH University Aachen. The Department of Information Management in Mechanical Engineering and the Center for Learning and Knowledge Management (IMA/ZLW) at the RWTH University of Aachen successfully implements the concept of project-based learning in the "Communication and Organizational Development Lab" despite the high number of participants.

The Communication and Organizational Development Lab is scheduled for the first semester in the bachelor-degree course of mechanical engineering and takes place in the form of two mass events with up to 1400 students overall. The lab features practical application and testing of the previously gathered theoretical knowledge. During the 2-day lab the students undergo an organizational development process: in groups of 25 they start a fictional company with various departments in the automobile industry, set goals, develop corporate strategies and build a prototype of an innovative soapbox. Led by the simulation, the students' actions reflect on their team and they need to build requirements for a successful teamwork. Good logistics (25 areas with identical equipment) and strictly following the schedule are essential for the successful completion of the project.

The students are responsible for their group achievements, tutors interfere as little as possible. After a short theoretical introduction into communicational and organizational theory, students have to solve the problems with their own knowledge. The tasks are defined in a way that challenges the students to solve them within the predefined period of time. Thus, the students have to work with the little information that is given and understand that their theoretical knowledge helps them complete their tasks.

With the help of different exercises and activities the participants prepare presentations, which they later present in the plenum. In this way key competence like presentation, creative techniques and problem solving behavior in the work process are conveyed. Each group is supervised by two tutors from the Department of Information Management in Mechanical Engineering and the Center for Learning and Knowledge Management (IMA/ZLW).

Self-reflection sessions are carried through after each work step and at the end of the course. Participating in the Communication and Organizational Development Lab students actively develop valuable professional skills by coping with realistic problems and solutions and are encouraged to take responsibility for their own learning.

6 CONCLUSION

Despite the disadvantages of lectures with high numbers of students, large group study courses will be unavoidable in tertiary education. Still, the fundamental change in university didactics toward a student-centered perspective does not mean that traditional functions of "frontal" teaching and receptive learning will not retain an important significance at universities. In fact, to improve the study situation it is rather about generating an expansion of the didactic action repertoire where teachers create new learning environments beyond classical lectures. These learning environments then can be successfully used to supplement lectures and to allow for active learning of the students. Given the rising shortage of skilled workers especially in engineering, the quality of teaching has to be improved in order to reduce the high drop-out rates.

As presented in this paper, project-based learning is one effective form of student-centered learning that provides a variety of professional skills and abilities needed in the 21st century workplace. It empowers learners to integrate theory and practice, to apply theoretical knowledge and thus provides them with professional skills. However, it is still a big challenge to implement project-based learning also in large group study courses. The case study of the course Communication and Organizational Development for engineering students illustrates, though, that even with large group study courses the application of project-based learning is possible.

As a central future task for higher education research further innovative concepts have to be developed that shape the change from a teacher- to a student-centered perspective. Concepts of student-centered learning such as project-based learning have to be adjusted to fit large group study courses. Appropriate concepts for study courses in engineering science have to be enhanced/ improved and tested in practice. This task is significant if nothing else to assure the connectivity of scientific education to entrepreneurial and social practice.

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