Engineering Pedagogy at Universities in Saxony - Insights into a research and further education project of Dresden University of Technology and University of Applied Sciences Zittau/Görlitz

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Abstract:

This article describes a cooperative project of Dresden University of Technology and the University of Applied Science Zittau/Görlitz. It introduces the structure of this project and the curriculum of the postgraduate learning program for the development of specific teaching and learning competencies for engineering teaching staff in academic settings. Furthermore it describes relevant results of an empirical requirements analysis that has taken place to realize this cooperative project. Subsequently, the author gives some insights into one module of the curriculum.

Keywords: university didactics, engineering pedagogy, training, curriculum

I. PROJECT BACKGROUND

Understanding of engineering pedagogy

The origin of engineering pedagogy and its tradition in Dresden can be traced back to the establishment of the Institute of Engineering pedagogy by Hans Lohmann in 1951 [1]. His approach towards an engineering pedagogy was developed further over a period of several years. Today we know two views of engineering pedagogy that have to be distinguished by their target groups of teaching:

1. Target group of teaching: engineering students

This point of view condsiders the requirements for future engineers in terms of social-communicative activity in modern structures of production and service as well as the design of teaching and learning processes for the development of adequate qualifications.

2. Target group of teaching: engineering university teachers

This point of view requires the design of a needs-based engineering education, especially the design of technical and technological-specific teaching and learning in academic engineering education.

Starting point in Saxony/Germany

Saxony arose to a strong industrial region over the last 20 years. The highly qualified employees that are necessary for that process are mainly educated and trained at universities and universities of Applied Sciences in Saxony. The Ministry of Education and Science (BMBF) and the Association of German Engineers (VDI) already determined a lack of engineers which will increase in the future several years ago [2], [3], [4]. In addition to the skills shortage in structures of production, services and research in particular, the general demographic trend is a reason for that problem in Germany. The Federal Statistical Office prognosticates a reduction of work force by 5 million people (10%) for 2030. The tertiary education sector of Saxony has to deal in an intensified way with the demographic trend and its negative outcome in the coming years. Student numbers are likely to decrease by 40% [5].

To compound these challenges, German society as a whole faces specific problems in the different fields of engineering. This includes low numbers of graduates in engineering study courses and adverse mentoring and a high dropout rate in engineering study courses [6]. Furthermore modern academic teaching demands changes in teaching arrangements to allow more autonomous learning activities in didactic teaching and learning designs.

II. THE PROJECT E-DIDACT

The TU Dresden and University of Applied Sciences Zittau/Görlitz realized the cooperative project “E-Didact – Engineering pedagogy at Saxon universities” from 2010 to 2012. Under consideration of offered study courses at the University of Applied Sciences Zittau/Görlitz the aim of the project E-Didact was to develop, to implement and to test a study course in university didactics. A tailor-made science-based study course to both meet market requirements and to develop competencies by designing teaching and learning processes for academic engineering education was developed throughout this project. E-Didact also served as a pilot project for other universities in Saxony.

The aims and content of this study course are geared to the specific issues of engineering education at universities of Applied Sciences and their close connection of research and practice.

There were four phases in the project. The fundament for the development of the study course and its curriculum was

the analysis of the needs in university didactics. For this purpose a group discussion, partially structured interviews as well as observing teaching sessions with the university teachers at the university Zittau/Görlitz and the analysis of documents were undertaken. This phase was followed by the structuring and the developing of the curriculum and its modules and units. After this the study course was implemented, tested and evaluated. The last phase was used for sustainability, documentation and increasing steadiness of the project results.

Identified qualification requirements

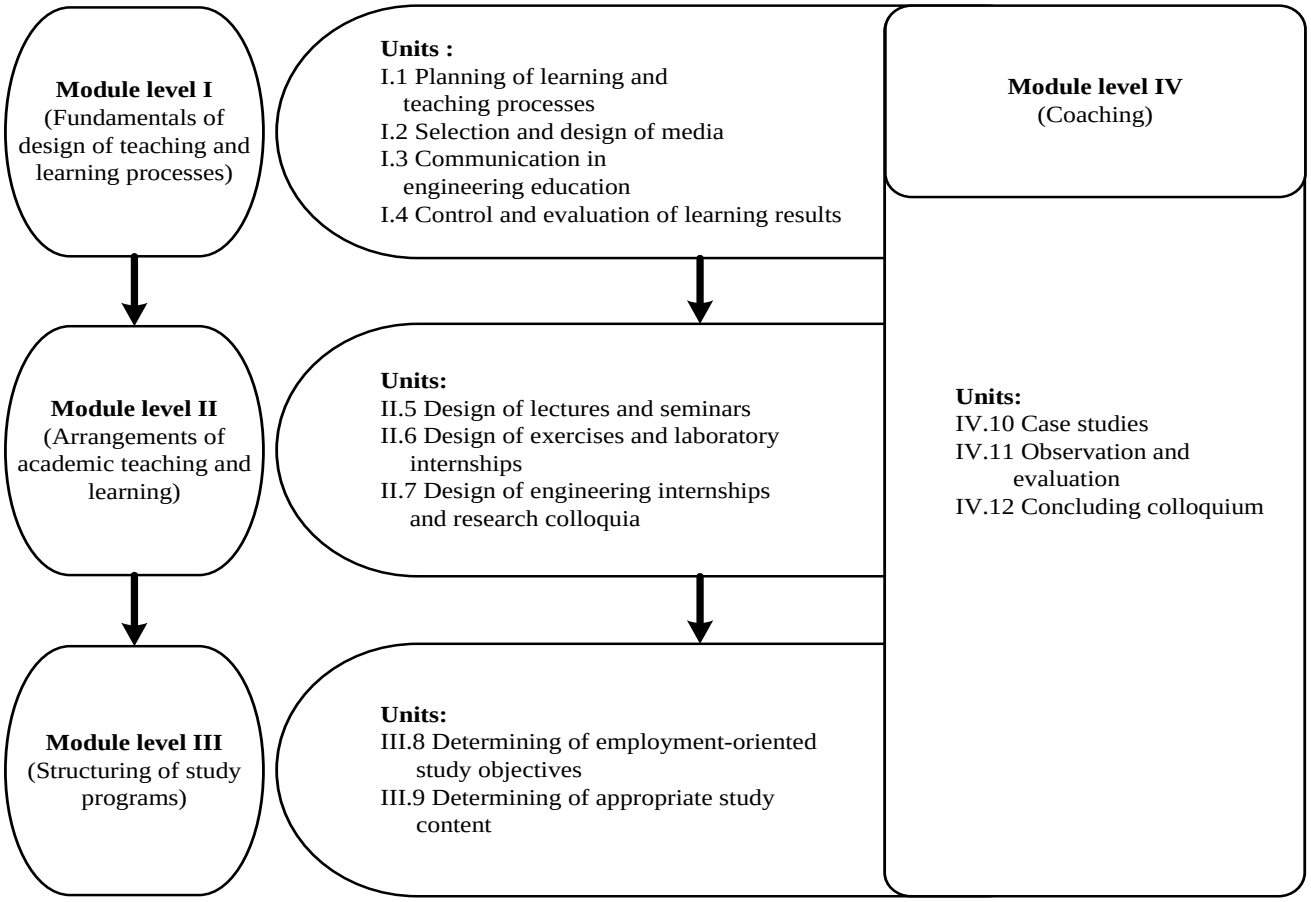
About 60 university teachers and lecturers participated in the group discussion. The participants could be distinguished in two groups: teaching staff with an university didactical education and teaching staff without an university didactical education. In summary the following needs of qualification are the results of the group discussion, the partially structured interviews and the observations of teaching sessions [7]:

a) For teaching staff with university didactical education
- The use of special types of teaching and learning in engineering education
- Special problems in designing examination processes
- Developing an open and positive feedback culture
- Evaluating courses

b) For teaching staff without university didactical education
- Didactic basics in planning, performing and analyzing academic education processes
- Selecting and designing of didactic media
- Designing of communicative processes
- Control and evaluation of learning results
- Using didactic methods in study courses
- Structuring of study courses.

For the specific needs of qualification of teaching staff with university didactical education it is possible to offer workshops or personal coaching. Fortunately, there is already a suitable offer at the University of Applied Sciences Zittau/Görlitz and other universities in Saxony.

However, there was no systematic curriculum for a university didactical study course especially for engineering teaching staff without university didactical education. The development of such a curriculum was the main issue of the project E-Didact. The following outline of a curriculum is the result of this research process:



A closer look at the scheme of the curriculum in picture 1 shows a structure of four distinguished module levels. Essential parts of module level I are fundamentals of design of teaching and learning processes. The aim of unit 1 is to qualify the participants to design teaching and learning processes in engineering education under consideration of scientific principles and knowledge as well as educational objectives and the specific needs of the target group.
Moreover, the participants acquire knowledge of didactical terms and media as well as their functions in teaching and learning processes, an introduction to the didactics of media studies and its basic approaches. Furthermore, the main aspect in module 3 is a target oriented design of adequate teaching relevant communication processes. Chapter 3 shows this module in detail.
Module 4 focuses on the science based and purposeful design of control and evaluation of learning results that means personality traits, qualifications and competencies.
Based on these fundamentals the main part of module level II are arrangements of academic teaching and learning. The participants are qualified to plan, to teach and to follow up on their lectures, seminars, exercises and internships considering the needs of their target group and the educational objectives. Another unique selling proposition of module level II is the didactic of laboratory work. This module focuses on the target oriented design of teaching and learning processes in laboratory work and attendant self-study phases.
Whereas module level II focused on the microscopic didactical level in module level III the macroscopic didactical level of engineering education is predominant. The participants are qualified to deduce science based, to structure and to describe the aims of study courses and modules as well as the necessary content for engineering study courses of a specific engineering discipline.
The units of module level IV especially coaching of the participants ensures the realization of the practical support during this university didactical study course for engineers. Case studies are used to enable the participants to apply schemes for planning teaching and learning arrangements in a autonomous way. This is followed by observations of teaching sessions of colleagues and participants as well as self-monitoring processes for documentation, analysis and evaluation of own lectures.
This process goes along with seminars which support the participants during the acquirement of knowledge and skills for a continuous professionalization of teaching. In the context of a concluding colloquium the participants are qualified to plan, to apply and to evaluate autonomously their own lecture.

III. Module I.3: Communication in engineering education

Below there is an exemplarily insight into the module I.3. The aim of the module I.3 is to qualify the participants to design teaching relevant communication processes and communicate with their student's purposefully and adequately under consideration of scientific knowledge about communication and personality traits of the communication partners. To realize this aim, module I.3 contains the following 5 units:

Unit	Topic
1	Basics in designing communicative processes
2	**Teaching relevant monological communicative procedures**
3	Teaching relevant dialogical communicative procedures
4	Conflict management
5	Basics in intercultural communication

For example unit 2 (Teaching relevant monological communicative procedures) contains the following content:

- Process structures in dialogs, characteristics and performance spectrum of specific teaching relevant communication procedures
- Didactic principles in monological communication procedures
- Communication in written examinations
- General design elements of lectures
- Planning of speeches and presentations
- External and internal structure of lectures
- Pathes of cognition
- Verbal, para-verbal und nonverbal design elements of lectures and presentations
- Interaction of teacher and students

Communication in written examinations

In the following the topic „communication in written examinations" is outlined:

During the past years there were changes in tasks in examinations in engineering education. More and more importance was placed on autonomous problem solving. So the tasks became much more complex and required a competency to autonomously solve problems. This challenge intensified further against the background of the discussion about the adequacy of examination requirements and different cognitive levels of didactic orders. This discussion and the results of this research show that there is an imbalance of different cognitive levels in control and evaluation of learning results and it is often asked too much of students. This is one reason which causes poor marks in examinations [9], [10].

Furthermore, the increasing level of task complexity and the lack of a common understanding of tasks for lecturer and students increase the risk of a increasing lack of transparency [11]. These demonstrated aspects can influence on acting in examinations in a negative way and thus reduce the performance of the students.

To deal with this situation we can give some fundamental thoughts on the relation between language, teaching and learning. Learning without language is impossible. A teacher uses language to initiate and regulate learning processes as well as get feedback about learning status. So the teaching and learning in engineering education can be defined as a language based relationship of teacher and student.

Against this background the understanding of oral and written information in engineering education is fundamental for learning process, especially for acquiring and structuring knowledge and controlling and evaluating learning results.

Consequently, the intention of this unit is to enhance transparency of examination processes and a more adequate design of tasks in written examinations in engineering education by an explication of operators (verbs, which prompt specific acts) used in written tasks during lectures. This is followed by teaching the meaning of the explicated operators to improve a common understanding for teacher and students. The clarity of operators is not only necessary to improve a common understanding of tasks in examinations but also to get valid learning results. Furthermore operators represent different cognitive levels. Depending on the operator students have to reproduce or to produce knowledge or to solve problems or rather transform knowledge.

Consequently we need an instrument that can help to improve such a common understanding. We suggest didactic orders as such an instrument. With didactic orders specific acts can be initiated and operators are frequently used in it.

So we can define: didactic orders are verbal initiatives given by teacher which have different grades of intensity and prompt students to act with a learning relevant object in an expected or defined way. Didactic orders contain verbal encoded information which have been planned with regards to phases of instruction. They are used to prompt an expected specific act during learning process. Didactic orders can be tasks or incomplete tasks, problems, questions, guidances, instructions etc. [12], [13], [14].

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