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Invited Paper - Competence-oriented curriculum development for engineering-pedagogic training of academic teachers

Prof. Ralph Dreher PhD P.E., International Society for Engineering Education (G

Born 1965 in Neumuenster, Germany, 1984 High-School-Diploma, 1987 Diploma as Car Mechanic (vocational Education), 1991 Diploma as Teacher for vocational schools, 1993 PhD 1999- 2008 Lecturer at the Technical Universitzy of Hamburg and University of Flensburg, parallel working as Teacher for vocationl Education in the field of Automotive Service 2000 - 2007 Scientific Leader for three projects for training Teachers and academich staff in the field of engineering in Germany, Bangladesh and Austria 2008 Full Professorship for Didactic of vocational Education at the University of Wuppertal 2000 Member of IGIP (International Society of Enginnering Paedogic); 2005 Co-Author of the ING-PAED-IGIP-Curriculum to become Enginnerin-Pedagogist; 2006 - 2010 EC-Member of IGIP 2010 research Director of IGP

Competence-oriented curriculum development for engineering-pedagogic training of academic teachers

Abstract
The following report explains, why it is necessary, to train academic teachers by using a "competence-oriented" curriculum. That means, to give the teachers the chance, to work project-oriented and to learn to reflect their own working and problem-solutions in teaching. To demonstrate the possibility of such curriculum, a prototype was developed by using the methods of vocational-science. That means to analyze the work-processes of academic teachers about their core work-tasks and to transfer this to project-based modules of engineering education.
Keywords: PBL, PBE, TVET, Bachelor, education

Problem in brief: About the duality of engineering BA Courses of study

Concept of engineering BA/MA Courses of study

The concept of a BA course of study resulting in a professional qualification with a MA course of study building on that has become globally accepted.

However, after the implementation of a BA/MA- concept in Europe ("Bologna-Process"), it has become apparent that the concept of separating a practice-oriented application orientation (BA) and a scientific research orientation (MA) is not target-aimed, particularly with regard to ambitious occupational groups. This is because in practice a challenging profession encompassed the necessity to and the responsibility for design, which means to assume responsibility for how to act professionally, as well as for how to deal with the consequences of these actions and also to determine to which extent an optimum has been accomplished or its reasons for a failure. Thus, the implied demand for a social, environmental and economical responsibility of ones own actions characterizes the modern and likewise practice-oriented concepts of vocational education. In view of this development in the field of vocational education and taking into consideration the fact that each individual has to be able to fill a big spot in the larger scope in the flat personnel hierarchies of current concepts of conceptualizing and producing, a scientific engineering university education is not able to close its mind to these progressions.

This means that: With all due respect to the importance of practice-orientation, meaning the facilitation of preplanned resp. previously tested solution strategies, a scientific engineering course of study on has to allow for the students to analyze these strategies with regard to their value, to recognize their strengths and weaknesses, to fathom their possibilities and restrictions and to reflect on their usefulness and accountability in a way that impacts ones own actions. These processes make an examination of the surrounding society and the, thus, developed philosophy and, ultimately, the penetration of the surrounding culture in terms of Humboldt, necessary and have turned into a fundamental feature of BA course of study. The ability to act independently and self-regulatory based on a system of values, which constantly differentiates itself constantly, appears to be a basic requirement for scientific engineering work to be able to operate innovatively and efficiently. This is (with a look to the European and in special case the German Situation) the only explanation as to why the EHEA (European Higher Education Area) has declared the fostering of these actions as the essence of BA Courses of study (Cf. in addition the EU's demand voiced in the program "New skills for new jobs", which perceives the fostering of the previously presented skills as a key characteristic of BA-Courses of study [1]).

So it is useful to understand, that BA-Courses have two functions (or that it is a duality). They must prepare directly for vocational working by training the special (practical) skills and (theoretical) methods of the Engineering discipline, but they also must educate the students to become self-reflected parts of the society.

Competence-Development as primary aim in Engineering Eduation

Looking to the duality of BA-Courses described above, the responsibility of academic staff in engineering education is to develop the competence of their students. This means, looking to the definition of competence as the disposition to solve problems in a responsible fashion, that the students should often work in teams with case studies.

While working on and solving the case studies, the students will not only learn specific engineering knowledge, but they will also be taught to understand the value of this knowledge and how it is used. Thus, they will simultaneously develop their methodology and social skills.

But it is a new challenge for the academic staff (special in research-oriented Universities) to create such case studies ("problems") on the level of BA-Courses and to moderate the process of problem solving within the groups of students.

Moreover, often, the academic teachers get the wrong idea, thinking that it will be better to instruct the students like it was done in the "good old times".

Therefore, the core idea of a competence-oriented curriculum of engineering-pedagogic for academic staff is, that it is also competence-oriented and will work with case studies. Hence, the academic teachers have the chance to understand how fruitful this way of learning is and that it is a great chance to develop competences during their own process of learning:

TEACHER`S LEARNING BIOGRAPHY = HIS STYLE OF ENGINEERING EDUCATION

Following this simple awareness, the Education Staff for Engineering Education must be trained with the same (competence-oriented) methods as it is fruitful for the students. That means in fact: Looking to the idea of HAVIGHURST about principle of task-oriented learning [4], the curricula of Enginnering Education for the training staff must be dominated by PBE-oriented Development-tasks a core elements (Modules) of the curriculum-structure..

Short Explanation: From PBL to PBE

PBE as a further development of PBL

Project Based Learning (PBL) does allow for a domineering orientation on real-life engineering scientific problems throughout the whole course of study. Furthermore, it fosters the ability to learn individually, work in interconnected project structures and, thus, above all the fostering of communicative skills. However, the concept lacks the component of fostering internal as well as *external reflection,* which turns out to be one of the key qualities of an engineer according to the previously presented argumentation.

Hence, *learning* is no longer the dominating characteristic of the future's scientific engineering course of study. Instead, the BA course of study is to be understood as a process of *educating*. Education throughout such a course of study is achieved by presenting the students with appropriate complex engineering tasks. These tasks are primarily tailored to foster the ability to work by making sure that the solution process is dominated by questions on ones strengths and weaknesses, the values of ones work, the likes and dislikes of certain solutions for problems, the allocation of roles within the project's network, the accountability and its outward presentation etc. must reflect by the students. So, each student become an idea about his personal strength and weakness and what is to do in the next step of his education as engineer in the fields of engineering, methodology and social qualifications.

Thus, a course of study through project work with the integrated element of group- and personal reflection as key for education, labeled PBE (Problem Based Education) in the following.

Characteristics of a PBE-oriented qualification of lecturers

Lecturers who implement the concept of PBE and, therefore, want to fulfill its aspiration for continuous reflections have to be able to:

- Select project tasks appropriate for vocation and education
- Purposefully supervise project groups (maintain project and group status)
- Ask situationally appropriate questions of reflection, which allow for an individual (!) personal development
- Constructively chair emotional challenging phases of reflection

According to existing experiences of the lecturer qualification, the conveyance of such skills is not accomplished through a theoretical penetration of the learning theory behind the concept (which naturally has to be taught, however, is not key) and also not with the help of the development of strategies for a didactic decision-finding and conversation techniques. Instead, the fact that lectures tend to prefer teaching methods with which they have successfully learned has to be taken advantage of [2].

Proposal: PBE-oriented curriculum in teacher training

Key characteristics of the modules

In compliance with the previously constructed principle, a PBE-oriented curriculum should present lecturers with the opportunity to experience processes of reflection in tangible vocational tasks as part of their own biography of learning during their engineering pedagogic education.

Consequently, such a curriculum has to feature self-contained units of reflective learning of essential engineering pedagogic tasks– modules, which respectively include an engineering pedagogic task and are to be worked on reflectively.

Crucial is not only the content of such a module but also that the modules individually show specific moments and strategies of phases of reflection.

Content and string of the modules

Regarding the definition of the contents of modules, methods of vocational scientific macro analysis have been used [3]. This means that based on work observations and workshops with lecturers and experts the various types of classes have been identified as essential in Fig. 1:

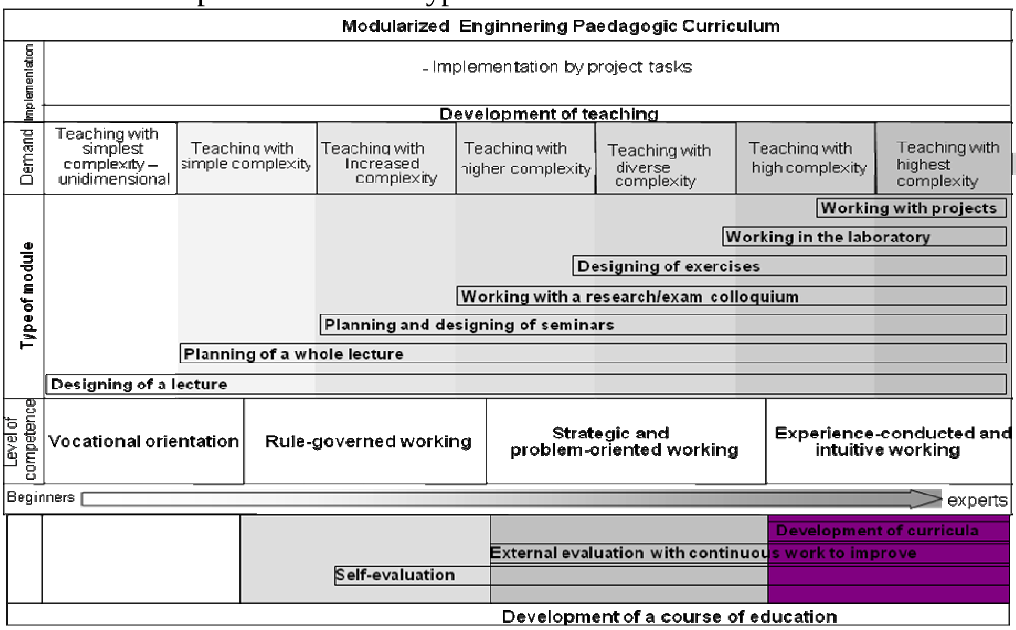

Fig. 1: Structure of a modularized EP-Curriculum

The string of the tasks from "Designing of a lecture" through to "Working with projects" acts up to the developmentally logic principle of learning, fundamentally described by HAVIGHURST with his "Developing Tasks" [4], DREYFUSS/DREYFUSS with the subsequent

principle of novice to expert [5], further developed to a structural moment of curricula and NEUWEG [6] with his term of salience:
Occupational problems, which, depending on the training location, allow for a certain degree of complexity, are to be chosen carefully. This means that they should not refer to explicit or default solutions or their approaches ("solution space", which allows for individual and personal but always justifiable decisions). This space for solutions and, thus, their scope for design are to grow with increasing length of the training and by taking into account the previously gained experiences – the task is to become more complex [6]. In correspondence, the necessity of reflection has been basally embedded in Fig. 1 below: Self-evaluation is part of each phase of development (which inevitably includes the process of reflection) and later on complemented by the module component "external evaluation" (includes feedback from students and teachers).

Curricular description of a module

For a start, the structure of a curriculum, presented in Fig. 1, gives an overview on a PBE-oriented engineering pedagogic curriculum. However, CP-requirements, module organization, concrete training contents and mandatory causes for reflection are not mentioned.
Therefore, each module has to be described in a curricular manner. Attention has to be paid to the fact that these descriptions have to present an obligation on the one hand, but allow for flexibility on the other hand, so that the curriculum can be implemented in various locations. Thus, it seems to be sensible that the module descriptions are made of the same categories, which specify extent, contents and methods along with different options for their implementation. The following paragraphs will describe the module "Designing of a lecture" and is to be seen as an example:

- Module: "Designing of a Lecture" (2 CP)
- Aim: Designing a lecture within 90 min in the preferred scientific discipline
- Exemplary content: Types of teaching, typical structure of lessons (phases), usage of media, basics of learning psychology and social-class-analysis, typical systems to decide social form, media, the role of the teacher and the students and needed time, planning-scheme, evaluation-systems for lectures.
- Result: Planning, teaching and evaluating a lecture of 90 min
- Reflection (two systems recommended): Self-evaluation by using the planning-scheme, interview with students, structured feedback from colleagues with guideline, self-video-analysis.

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