DEVELOPING PBE-ORIENTED CURRICULA IN THE FIELD OF ENGINEERING SCIENCE

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Abstract: The paper will at first show, that "Engineering" as vocational profession will not only develop new products and services, but also will be a big part of changing possibilities and consequences. So Engineering is in first a technical discipline with roots in natural science, but it has also a part of social responsibility. The main thesis is, looking to this fact, that future engineers must learn in their study courses both parallel: Constructing and designing AND Responsibility and social communication. As benchmark for this type of curriculum was formulated the "Leonardian Oath" and as consequences, it was developed a PBL-based curriculum for engineering science. The core idea of this concept is, that students only can learn responsibility and social communication by REFLECTING their own construction design-work.

Keywords: PBL, PBE, Leonardian Oath, Responsibility, Social Communication

THE "LEONARDIC OATH" AS BENCHMARK OF CURRICULA IN ENGINEERING SCIENCE

Engineering work means to create the technical requirements for a world without famine and epidemics but with open access to fresh water and information, education for all and more equality and sustainable development – so engineering work should be oriented and pledged towards the following two guiding principles:

• The "transfer competence" to realise a solution and

• the "responsible competence" to be aware of the effect of this solution for the problem itself as well as for the social, ecological and economic environment.

That means, the core task of engineering work is to be realised as a dualistic function. This idea is not a new one, it is the basic rule to realise technical impact assessment. However the ethical component is a future-oriented one, concerning to our worldwide situation. It is also a clear fact to note that engineers often work to renew or to create "over engineering" products only to have incentives, which attract customers – an essential lubricant of the capitalism, which dominates political decisions.

Concerning engineering educators, this idea implies that Engineering Education has to amalgamate this dualism by:

• designing and realising curricula, which will enable to develop both, "transfer" and "responsible" competences on the basis of defining aims, learning outcomes and systematically structured and linked contents of the study-programmes, and

• creating teaching and learning styles, which facilitate students in all their diversity to develop their qualification in transferring and designing.

Future-oriented engineering curricula must mirror that dualistic function. Looking to this, it seems be useful, that there is a common benchmark for the processes of curricula development, course-design and accreditation.

So as benchmark for designing new Curricula in Engineering Science (and looking to the "Oath of Hippokrates" in medicine) a "Leonardic Oath for engineers" was created. Looking to the millennium goals of UNESCO (UN/ECOSOC, 2012), this idea follows the main requirement of Engineering Education, that engineers must become more concretely support to focus their work by using the categories of "sustainability", "capacity building" and "society faced".

The actual form of the "Leonardic Oath" reads as follows:

"Every Study-course of Engineering must be based on the idea, that engineers will be educated to use their technical knowledge with their design-responsibility oriented towards the principles of

- *ethical egitimation,*
- *sustainability and*
- *societal checkability." (Dreher, 2015 pp.714)*

WHAT MEANS PBE?

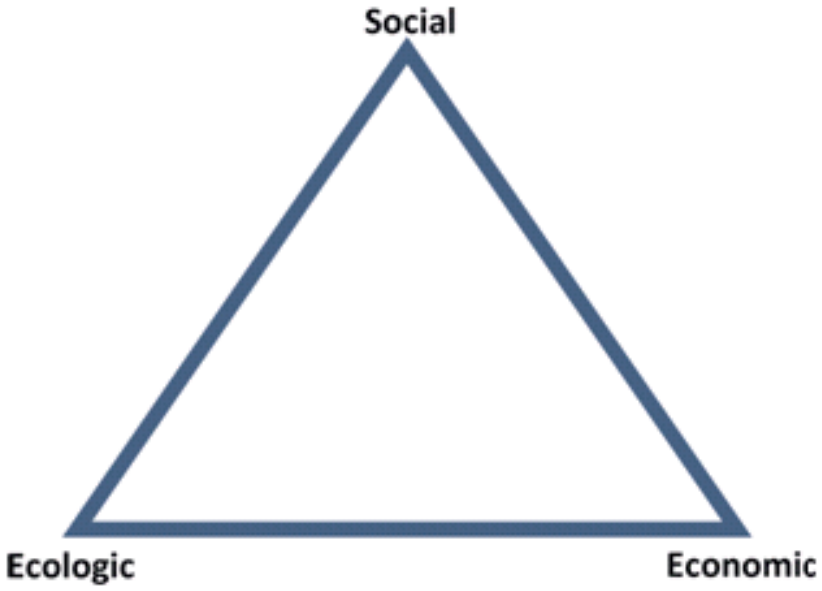
Problem-Orientation as Key-Function

To realize the training in nature and engineering science and to develop parallel the social competences of young engineers as it was given by the "Leonardic Oath" means in core, to give the students a chance, to develop and to reflect an *own (!)* solution.

To give them a chance for this, their study-courses must be designed as courses,

- which are not offer knowledge, methods and (discipline-typical) solutions, but which
- *offer a problem (!)* in line to their specific development-level as main content. In a way with a high level of self-directed-learning and supported by micro-teaching units, which will be offered for each course, the students will develop their own solutions including an internal reflection using the "triangle of sustainability" (Fig.1):

Figure 1: *Triangle of sustainability*



Problem-Solving as key for Competence-Development

In the general actual meaning, "Competence" as Main-Aim of Education means to develop the possibilities of the students, to solve *self-organized* (Erpenbeck and Heyse, 2007) problems as design oriented task (Rauner et.al., 2009).

So students (in accordance to Fig.1) must have the chance, to train their skills and possibilities,

- to understand a problem in their discipline and
- to create innovative and responsible self-solutions for by
- using the factors of ecologic compatibility, economic feasibility and social acceptance.

During this process, students will grow up the base of competence – an "implicit" or "tactical" knowledge, which they are not directly able to verbalize, but which is steering their decisions, meaning und doing (Neuweg, 2004).

So study-courses, which will follow the "Leonardic Oath" and his general idea – to educate engineers, which are good technicans and innovate parts to develop our society – must work problem-oriented, because only in offering a problem as didactical base, gives the students a chance for a parallel development of their discipline and social competences.

Reflection as a main-part of Education

A great misunderstanding by using problem-oriented course-forms is to give the students the possibility, to develop solutions, which are working, but not to use the benchmark of sustainability as a main topic for a reflexion, if the presented solution will be really the Best-Case-Solution.

The process of Reflection will be the most important part of a problem-based study-course – especially the moment, when the students will get impulses for their inner reflection during the process of outside-reflection (so that moments of "assimilation" during the project-work in the with the example of the actual problem will be initiate in best-cases problem-independent moments of "Accomodation"; see Piaget, 1992).

Coming to these moments of Accomodation means, to change or better to develop the factors of behaviour of the individual students – and in this moment, the process of Problem-Based *Learning* (PBL) becomes a process of Problem-Based-*Education* (PBE).

PROPOSAL FOR DEVELOPING PBE-ORIENTED CURRICULA

The main question to develop study-courses by using the general idea of PBE is how a PBE- oriented curriculum can be designed.

Because only with such curricula as base, the following developing steps (e.g. Lecturer-Training, accreditation processes, course-plans, examination forms, footprints for the buildings) are able.

So the following steps A-D will be understood as a general proposal to develop PBL-oriented Curricula:

Criteria for Engineering-tasks as Course-Content

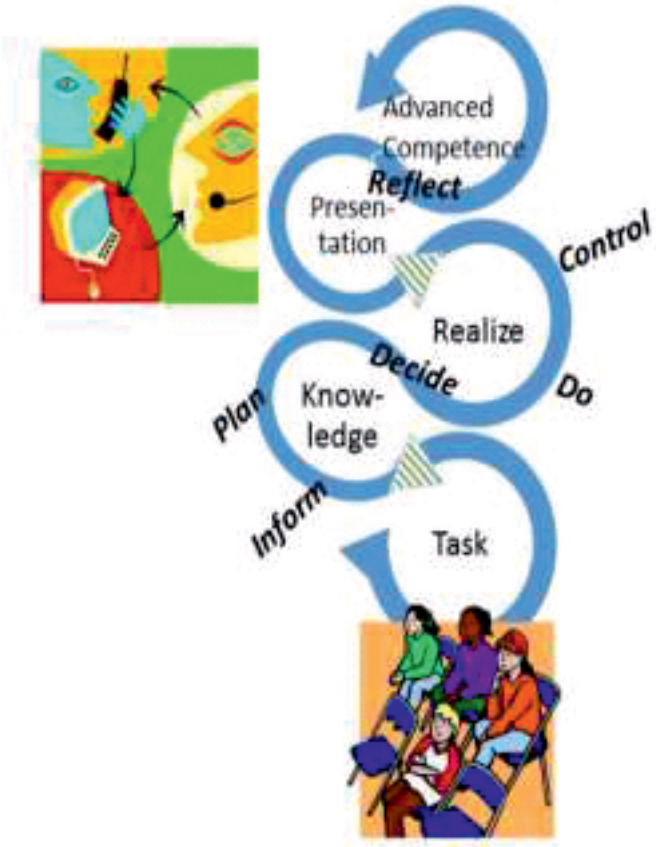
Looking to the question above, it seems necessary, that the courses in Engineering Education will directly base on engineer-oriented tasks. The reason: Only in this case, the

students will develop or create an individual solution, which can be reflected by using the criteria of the "Leonardic Oath". The "Art" of curriculum-design or better of transformation a curriculum in courses, is to find tasks, which guarantee at first a reply intersection with the specific engineering knowledge of the task-oriented part of engineering work and which further allows a lot of *specific* solutions to reflect the design competence (as collective name for the possible of a human being, to understand and to design an own responsible solution) of the students. As a result, the task must integrate the possibility of a "multidimensional solution space".

Course-structure

A typical structure of such a course will give in Fig. 2 and will show that academic courses in the case of developing design-competence must follow the principle of a fulfilled action with the steps Inform, Plan, (Decide), Do, Control and Reflect:

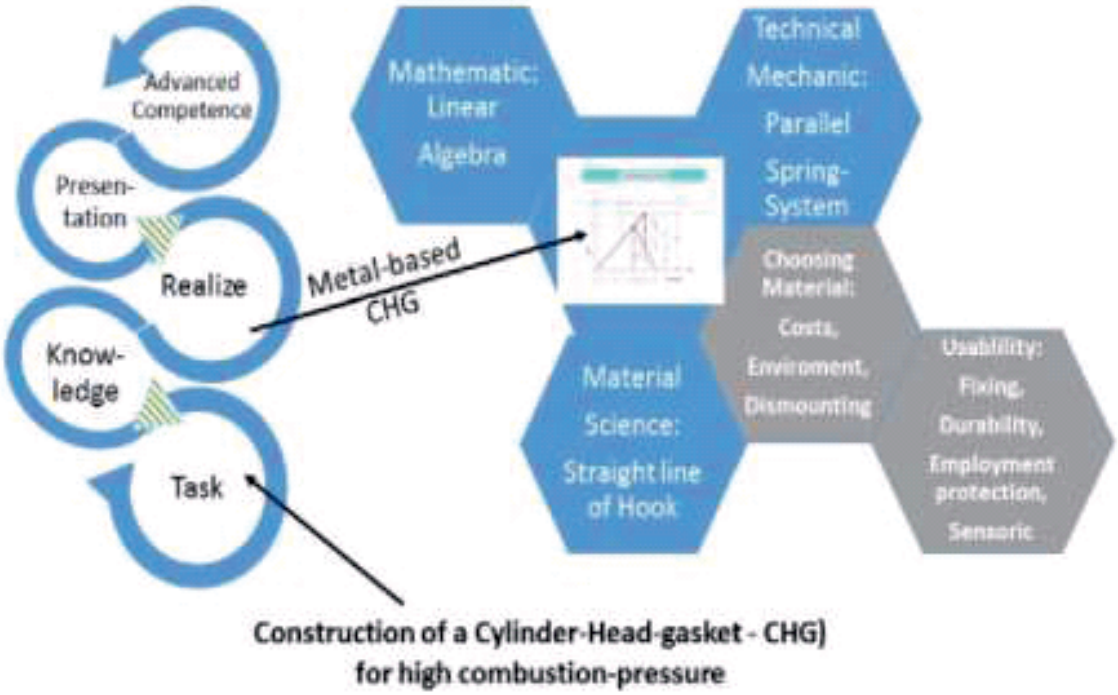
Figure 2: *Course-structure*



Combining task and specific knowledge

After choosing an identified part of engineering work as course-able task (in most cases by using the methods of Vocational Science, the knowledge-content of the case must be analysed to identify the Micro-teaching-units behind the task. Fig. 3 shows this using the example to create a new cylinder-head-gasket for Diesel-engines with a very high combustion-pressure as engineering task:

Figure 3: *Example for an education-arrangement*



Preparations

Working with concepts means to shift the main part of work in academic teaching from the part of teaching in the part of planning, because during the phase of preparation the teacher has to

• find realistic engineering tasks, which (in sum) guarantees that the whole study program, with all its topics of specific knowledge of the engineering-discipline will be broached;

• define an evaluation criteria for the self-controlled part of the students for the end of the whole phase of „Knowledge and Realize" (Fig.1);

• create the micro-teaching lessons together with the colleagues from the other academic professions (like „Straight line of hook" in Fig.2); plan the phases of presentation and in main for reflection by using special methods for self- and outstanding-reflection.

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