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How to make Engineering Students master problem identification and problem formulation

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Abstract

The focus of this paper is how we make engineering students master problem identification and problem formulation. The authors take inspiration in their own experiences as lecturers and supervisors in a PBL learning environment at Aalborg University to develop a workshop. Aalborg University has a rather well-defined approach that takes the engineering students through different phases in order to develop these skills. The workshop aims to engage participants in an exemplary process, where they reflect upon their problem understanding, their own knowledge as regards problem identification and problem formulation and the skills needed to formulate an authentic problem and argue for their relevance. Being the target group of this workshop, academic staff is also expected to reflect upon their own teaching practice and relate it to the need to enhance students' skills for problem identification and formulation.

1 Introduction

Active learning strategies prepare engineering students for a career of creative thinking and independent decision-making. A core premise of active learning is that students are responsible for their own learning and development of knowledge, skills and competencies. Examples of active learning strategies are CDIO, role-play, problem based and project organised learning (PBL). A lot of these strategies imply development of problem solving skills, which is one of the core skills for engineering practice and stressed by accreditation bodies (see for example, UK-Engineering Council, 2004; ENAEE, 2008; ABET, 2010). Even though it is rather straightforward for students to learn how to solve problems; identifying and formulating a 'relevant' problem is often a challenge and frequently neglected in learning processes (Felder *et. al.*, 2000; National Academy of Engineering, 2004; Shepard *et. al.*, 2009).

This paper proposes a workshop, which will enhance participants' skills in identifying, analysing and formulating relevant problems. By relevant problems the authors mean a problem that is well-argued in terms of need, authenticity and implications.

The following workshop overview and aims elaborates on the reasoning behind the workshop activities, whereas the consecutive activities section elaborates on the workshop structure and its different activities.

2 Workshop overview and aims

The workshop overall purpose is to provide to academic staff, and consequently students, an approach to enhance and develop problem formulation skills. To do so, the workshop is inspired by the authors' experiences as lecturers and supervisors in a PBL learning environment at Aalborg University. Aalborg University has a rather well defined approach that takes the engineering students through different phases in order to identify, analyse and formulate a relevant problem. The problem formulated is then solved and documented through a project period of approximately ½ year.

In this context a problem can be defined as a *wondering*, often originated from an observed phenomenon (i.e. situation, event, person or thing), between how things are (present state of being) and ought to be/could be (idealised or hypothetical way of being). A problematic situation causes contrasts, conflicts, contradictions, stress, frustration, sorrow and/or indignation, which impel people to act in order to change its current state. Problems do not have to have a negative character. They can also be defined as an un-explored potential of a situation or object (Borrows & Tamblyn, 1980; Qvist, 2004; Jonassen, 2011). For example, the primary function of a mobile phone is to make and receive calls, nowadays mobile phones include photographic and video cameras, agendas, emails, GPS applications and so forth.

The learning process starts with students being acknowledged with and involved in situations that can possibly be problematized and analysed. These processes are known as *problem analysis and formulation*. The analysis and understanding of what is observed (problematic situation) and what is aimed for involves the application of both emotions and cognition. In order to change a situation defined as problematic or potentially promising, students need to understand what is observed, why it is the way it is, how, where and when it can be changed. These are examples of questions which help to deconstruct and identify elements of the problematic situation. The problem analysis demands mobilisation of prior knowledge, understanding one's knowledge, analysing the situation and culminates in a formulation of a problem normally in the form of a question to be solved (Qvist, 2004; Savin-Baden & Howell, 2004; Jonassen, 2011).

The workshop aims to engage participants in the exemplary process similar to the one engineering students at Aalborg University experience every semester. Thereby the workshop's hands-on activities can serve as a specific example of a more general methodology of formulating relevant problems in engineering fields. By reflecting and generalising on concrete experiences of the hands-on activities the participants can reach a broader and more general understanding of how relevant problems can be formulated in his/her own field of study. In this sense, problem identification, analysis and formulation skills become a transferable skill, i.e. participants apply a similar approach to formulate new problems within their specific disciplines of study (Pedersen, 2008).

3 Workshop components

Three parts compose the workshop. (1.) The first part is an introductory lecture, where PBL learning principles are presented as well as relevant concepts (i.e. interdisciplinarity, problem theme/ area, problem statement, mind map, etc.). (2.) The second part is a set of hands-on exercises, where participants form groups and work with given tools to identify, analyse and formulate a relevant problem. (3) The third and last part is a sum up, where participants reflect upon the process they went through in part two and draw some conclusions. At Aalborg University, this reflection takes place mainly at end of semester, where students are call to reflect upon their own working and learning process and report it through a small report. . See the following table 1, where the three parts of workshop are laid out in more details.

Table 1 Workshop structure, content and goals

Parts	Content	Tools/ resources	Goals
(1.) Introduction	PBL definition and learning principles; Problem definition; Problem theme, area, and research problem/ problem formulation	PowerPoint	Define and understand PBL and its learning principles Understand different types of problems
(2.) Hands-on activities	Identify problem areas or themes (brainstorm) Mind map the problem areas Initial problem formulation Final problem formulation Evaluate the problem formulated	*Tool 1*: Brainstorm to identify problem area *Tool 2*: Organising brainstormed ideas *Tool 3*: Problem landscape *Tool 4*: Matrix for analysis *Tool 5*: Problem formulation *Tool 6*: Evaluation of problem formulated (checklist)	Develop an approach to identify and formulate problems Relate the hands-on activities (exemplary process) with competencies, skills and knowledge needed to formulate relevant problems within field of discipline
(3.) Sum up	PBL curriculum alignment PBL process as process and product oriented Development of competencies and skills Reflection on workshop process and generation of knowledge by using Kolb's learning cycle (Illeris, 2007).	PowerPoint Kolb's learning cycle and organisational cycle Open questions for reflection	Reflect upon the hands-on activities (experienced learning), generalise into the learning processes to develop engineering students problem formulation skills.

Tool 1 and 2 will bring out the potential ideas and organise them in an apprehensive structure arguing why they could be relevant problem areas to look into. Tool 3 and 4 will enlarge and enrich the problem area looking into relevant perspectives of the problem area and the potential problem solving horizon and thereby prepare for the first initial formulation of a relevant problem. Tool 5 and 6 will help the participants formulate the actual problem formulation and evaluate the appropriateness of the specific question.

The sum up part is mediated/ chaired by the authors, where they also collect feedback from participants in order to revise and improve the workshop for future use, namely in staff training and teaching activities. Being the target group of this workshop, academic staff is also expected to reflect upon their own teaching practice and relate it to the need to enhance students' skills for problem identification and formulation. It is also aimed for participants to reflect upon their problem understanding, their own knowledge as regards problem identification and problem formulation and the skills needed to formulate an authentic problem and argue for its relevance. Thus, the authors develop the workshop by combining a series of hands-on activities and tools to engage participants in specific experiences; the followed discussion and reflection are part of summing up and aims to generate knowledge (i.e. interpretation and generation of knowledge).

Depending on the setting the workshop is expected to last for 1½ - 2 hours.

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