Expert in Teams Course Demands Work on Real Problems

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ABSTRACT
This paper presents an analysis and a discussion of the didactics of an Expert in Teams course offered at the University of Southern Denmark. In this course, engineering students shall develop their cooperation skills by participating in group work and by studying 1) idea generation/innovation, 2) developing collaboration and 3) development and refinement of a business plan. This study identifies that students often have to "unlearn" attitudes from their earlier studies. This shift in focus seems to generate some resistance to learning and can, to some extent, be demotivational and may hamper transfer of learning from the Expert in Teams course to other settings. To improve students' English skills, this study also finds that a need exists for more courses in English at earlier semesters.
Supported by literature of acquisition of learning on both the individual level and the group/organizational level, this study identifies that working on real problems forms a solid foundation on which to develop the essential engineering competencies of cooperation.

Keywords - Expert in Teams course, real problems, transfer of learning, cooperation

I INTRODUCTION AND PURPOSE

An important part of the engineering educational program at University of Southern Denmark (SDU) is that students develop competencies of working together in cross-functional teams. The Expert in Teams (EiT) course mixes together BA engineering students in their fifth semester from all different engineering educational backgrounds, and the course is considered a critical foundation to develop teamwork skills in cross-functional teams. In this course, between 400 and 500 students are split into themes in which two teachers teach, guide, and supervise about 40 students. These 40 students are then divided into groups of five to six students. Each individual group is mixed with students from different engineering educational backgrounds and, in most cases, one to two international students are placed in each group. The language taught at the EiT course is English, so because the majority of the engineering education programs at SDU are taught in Danish, some students will be challenged for the first time to study, communicate, write, and complete a final exam in written and oral English.
Students in the EiT course work on a project in which they contribute expert skills from their own educational program. The purpose of course is three-fold: 1) An innovative product or service idea must be developed in each group. 2) Based on this innovation, a business plan must be developed and refined. 3) Participants must reflect on how to develop work within a team setting and on how different collaboration models can be used to support the development of collaboration within a team. All three parameters are evaluated equally. The two teachers connected to each theme do some lecturing, but they primarily act as supervisors.
Prior to taking the EiT course, students have been studying with fellow students from their own educational program. Chemistry engineering students, for example, have not yet studied with students from the mechanical engineering program, the product development and innovation program, or the robotics program, etc. Thus, the EiT course often brings students out of their comfort zone, and the experience results in frustration and dissatisfaction. Some students express that they find the course to be a waste of time or that they simply hate the course.

Due to the common level of student resentment, it is especially challenging for a teacher to make the EiT course successful. However, the development of skills and competencies of how to work together in a project team is found to be important for engineers. More than a decade ago, Mette Buck Jensen (2006) proclaimed in the Danish weekly journal *Ingeniøren* that because 80% of engineers work in project teams, the ability to collaborate and to communicate in project teams is extremely important to become successful in engineering jobs.

Hence, the purpose of this paper is to investigate the following research question: How can real problems and didactical models best support the learning outcome of collaboration among engineering students?

This study is delimited in that it includes only the teachers' reflections on the EiT course. A questionnaire was sent to participating students, but once the course ended, students returned to their home universities all over Europe. Responses to the questionnaire came in at less than five percent and, consequently, were not included in this paper.

II LITERATURE OF ADULT LEARING AND TRANSFER

Dimensions of learning. Within the research field of adult learning and lifelong learning, Knud Illeris has developed several frameworks for learning. Figure 1 below illustrates a framework for learning inspired by Illeris (2003); learning takes place within three dimensions: 1) "Meaning/ functionality" which is regarded as cognition, 2) "Sensitivity/mental balance," which is related to the emotion and the motivation of the individual student, and 3) "Sociality," which is related to the interaction between the individual student and the group or the organization.

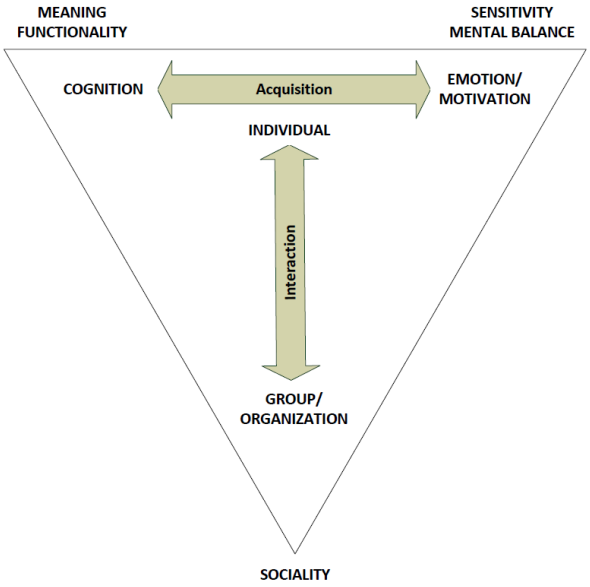

Figure 1. Dimensions of learning (Inspired by Illeris, 2003)

Figure 1 depicts how learning at the individual level (the horizontal level) takes place as a process of "acquisition" between cognition and emotion/motivation. The acquisition process depends on the individual student's ability to identify meaning of the acquired knowledge and on his/her individual motivation. If the student finds that what has to be learned will give a meaning to him and if the student is motivated, the acquisition of knowledge will be very high. On the other hand, if the motivation is low and the process of cognition is difficult, the learning outcome will also be low.

However, as illustrated on the vertical level in Figure 1, learning always involves others; interaction takes place with others. Figure 1 describes this component as "Sociality." Illeris (2003) identifies this concept

as in relation to society, but in this study, we focus on learning in the EiT course where group work and collaboration occurs. Figure 1 with regard to the EiT course demonstrates that learning takes place between individuals of a group and the organization, including the whole EiT course of 400-500 students and the individual theme groups of about 40 students. Learning in the EiT course is therefore considered to take place both in context between cognition and emotion/motivation on the individual level and in interactions with other members of the group/organization.

Transfer of learning from the classroom and to practice, as in a real job, has been researched for a number of years. In a very early study, Woodworth and Thorndike (1901) identified that if the learner experiences similar elements, the transfer of learning can be improved. The transfer of learning is particularly vital in the professional career paths of nurses, clinical doctors, teachers, and lawyers (Wahlgren and Aarkrog, 2012). Because 80% of engineers are expected to work in project teams, the ability to collaborate and to communicate is therefore extremely important (Jensen, 2006). The transfer of learning with regard to collaboration skills from the EiT course may therefore be important for engineers.

Transfer factors, unlearning, and the paradox in learning. Although it sounds logical, Wahlgren and Aarkrog (2012) demonstrated that, in particular, the student needs to be motivated towards what has to be learned. If students understand the goals and recognize the need for those skills, it will be easier for those students to transfer what has been learned into a new context. Metacognition is described as the ability for the student to understand that what is learned in practice is relevant to future situations. Accordingly, metacognition improves the transfer of learning (Wahlgren and Aarkrog, 2012). Further, Wahlgren and Aarkrog (2012) identified a paradox in the transfer of learning which calls for unlearning. When students attend a course, they want to learn new ideas and try new experiences. On the other hand, students also want to be safe and confident and to develop their habits and routines. Some individuals find it easy to be involved in a change process whereas others find it difficult. Wahlgren and Aarkrog (2012) determined that while students do seek new knowledge, they do not want to learn so much that they act differently. However, if the identity of the student is threatened, resistance to learning will occur. Students who are more experienced may face a need for more unlearning and demonstrate a higher resistance towards learning.

Wahlgren and Aarkrog (2012) state that overdoing learning, coaching, and supervision may create a foundation on which students become able to master the subject and improve their transfer of learning. The right climate for transfer and follow-up on what has been learned are essential elements in improving transfer of learning (Wahlgren and Aarkrog, 2012).

III WIND TURBINE BLADES - PROBLEMS - INVOLVEMENT OF EXTERNALS

This paper discusses the involvement of real problems from an external company researched during a particular EiT course which involved 38 students. In this section the involvement and flow of learning and issues related to this particular EiT course will be described from the teacher's perspective. Later, in Section IV, learning issues and transfer of learning will be discussed in relation to theory, and conclusions drawn in Section V.

The wind power sector has rapidly expanded in the northern part of Europe. For several decades, wind turbine manufacturers have developed and released new and larger wind turbines every 1-2 years. Made of composite materials, blades have consistently become longer, lighter, and optimized for efficiency. However, offshore wind power installations are subject to heavy changes in loads due to flap-wise and edge-wise bending, gravitational loads, torsion loads, axial loads, and pitch deceleration and acceleration (Katman et al., 2015). With problems from storms, lightning and heavy weather conditions, the manufacturers and operators of offshore wind turbines have identified a number of problems that impact the blades, including leading edge erosion, cracks in gelcoats, core failures, debonding, and delamination (Katman et al., 2015). Based on a literature study, the EiT teachers conducted a presentation of these problems, and a week later engineers from a leading European operator of onshore and offshore wind

installations exemplified blade problems at the EiT course. After these presentations and their own studies, students were expected to study these issues, develop solutions through innovation, create a business plan, and improve their collaboration skills through this study.
Students expressed that they found the presented issues exciting and that they thought the issues fit well with the group's diverse engineering backgrounds. They discovered that within their group, they were able to look at the same issues from very different engineering perspectives (from robotics, physics, chemistry, manufacturing, product development, innovation and global management, manufacturing and other engineering study programs). Other students felt that the presented problems were confusing to work on. Remarks made by more than one student were *"The engineers from the company just presented their problems but did not give us any tasks"* and "*Normally our teachers present a task and we solve the task."* However, at the end of the course and at the final exam a number of students explained that the presented problems constituted an excellent foundation for their group work. Some students explained that in other cases their colleagues participating in other themes of the EiT course had suffered from too simple tasks and did not have enough room to establish a solid base for a diverse group work.
Table 1 below illustrates the main process of steps presented during the EiT course. In particular, three issues wore found important to consider.

Table 1. Main steps during the EiT course

Week	1	2	3	4	5	6	7	8	9	10	11	12-15	16
	Intro. Formation of groups. Intro to problems.		Presentation of problem by involved company. Presentation of tools for collaboration.		Some students express heavy resistance to work on collaboration and to create a business plan.	Teachers supervise. Short business plan lecturing. Main phase of students' work.					Students present work for involved company. Feedback from peer students, teachers, and involved company.		Exam

The first minor issue was the establishment of groups from diverse educational backgrounds. Inspired from studies by Ravn (2007), students were asked to present themselves to someone they did not know, then each half minute the teacher announced to "change partner" and to repeat their presentation. Finally, each student filled out a post-it with his information, and the groups were formulated and visualized on a large paper sheet. This method proved to be an appropriate way to categorize the groups.
A second issue was that after the presentations from teachers and the involved company, students had to convert problems and develop these into something that they were able to study and work on.
A third major issue was that some 10-20% of the students, one-third of the way into the course, expressed negative attitudes towards working on the purpose of the EiT course; they did not find it relevant to work on the tools for collaboration and on creating a business plan. Instead, they wanted to focus more on the engineering tasks. In this case, the teacher found that he was under extreme pressure as a result of the negative attitudes from a significant percentage of the students. Ironically, their very resistance speaks volumes to their need to develop collaborative skills.

IV DISCUSSION

The development of collaboration skills among engineering students requires working on problems that call for diverse engineering skills instead of working on solving tasks given by the teacher. At the final exam for the EiT course, "real world" problems were cited by almost all students as important material. Cases from industry support student learning because different engineering perspectives contribute to a solution.
As shown in the learning triangle (Figure 1), inspired by Illeris (2003), learning on the individual level takes place as a process of acquisition between cognition and emotion/motivation. Within the engineering

domain, the tendency is to focus on cognition when a number of technical aspects must be learned. Most students explained that they were accustomed to solving tasks provided by the teacher; they were not as comfortable being asked to craft their own problem statements and solutions. Woodworth and Thorndike's early (1901) study establishes that if humans are given the opportunity to transfer learning to a similar setting, it is relatively easy to improve learning and to transfer that knowledge to a new setting. However, when students are in a course like EiT and are asked to work on problems and new perspectives, then motivation can be challenging. As Figure 1 shows, the acquisition of learning on individual level can be influenced. Figure 1 also portrays that the interaction within a group is important to facilitate a learning process; hence, the EiT course will be an important part when students must develop their collaboration skills in order to meet the requirements for participation in projects in future jobs.

Because 80% of engineers work collectively on projects the competencies of collaboration and communication are extremely important (Jensen, 2006). The EiT course and the purpose of collaboration may therefore be an important course to develop students' abilities to collaborate in cross-functional teams. However, one pedagogical element that must be considered is whether this course takes place too late in the engineering educational program. EiT occurs during students' fifth semester, and EiT teachers often experience a need for unlearning, negative attitudes, and resistance towards this course. According to Wahlgren and Aarkrog (2012), too much resistance towards learning hampers transfer of learning to a new setting. One potential solution is that a minor version of the EiT course might be offered during an earlier semester.

Students in the EiT course are frequently removed from their comfort zone. Some students have to read, write, communicate, and to take their final oral exam in English for the first time. Some students have to study together with international students for the first time. In many cases, students must give up their previous knowledge and attitudes as students from other engineering programs bring in new perspectives and may question learning gathered from four earlier semesters. Wahlgren & Aarkrog (2012) finds this to constitute a paradox in learning; most students want to learn something new—but not too much. The learning triangle in Figure 1 clearly illustrates the student's issues during the EiT course, including how the individual student in his acquisition constantly alternates between the cognitive process and his emotions/motivations. A major issue is that if too many changes are expected for an individual student, then student's resistance to learning may be too high and this serves as a barrier to the cognitive process. This course demonstrates that there may be a need for English-only courses at earlier semesters to avoid challenges related to too many parameters at the course.

The involvement of real problems presented by employees from an external company supported by elements from research seems to constitute a solid foundation when students from very different educational programs have to study and develop skills of innovation, business plans, and collaboration. It seems to be important to work on problems and not on tasks; problems give much more robust perspectives where students can chose their own focus, which fits the skills needed within the group.

V CONCLUSION AND FURTHER RESEARCH

The purpose of this study has been to study how real problems and didactical models can support the learning outcome of collaboration among engineering students.

The study concludes that a course like the EiT course at the University of Southern Denmark constitutes an important part of a learning program to become an engineer of the future, where engineers are expected to collaborate in cross-functional project teams.

The introduction of real problems – and not on tasks – creates a solid foundation on which students are able to develop their study in a number of different directions; that diversity enhances the specific groups gathered together from different engineering educational programs.

The didactical model illustrated in Figure 1 constitutes an important model for the teacher's preparation and for discussion with students about how to improve collaborative learning. The model shows its particular relevance to support both teachers' and students' considerations of cognition vs.

motivation/demotivation on the individual level of learning and to support learning through interaction between the individual student and the group or team in which learning occurs.
This study also identified that students in the EiT course most often have to unlearn attitudes they have previously learned. This awareness seems to create resistance to learning and can, to some extent, be demotivating; it can, in fact, hamper transfer of learning from the EiT course to other settings in some cases. However, when engineering students have to develop competencies of collaboration the development of a minor EiT course may be needed during an earlier semester. There may also be a need for students at earlier semesters to study courses in English and in that way to become more comfortable developing their English skills earlier.
This study is based only on the teacher's reflection of an EiT course. A more in-depth study is planned for a future semester; an examination of the whole timeline of the EiT course from the beginning of the course to the final exam will occur. In such a study, the students' motivation, tasks vs. problems, learning about collaboration, knowledge of business plans, and comfort level with English will be investigated further.

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BIOGRAPHICAL INFORMATION

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