1st Annual CDIO Conference
Queen's University
Kingston, Ontario, Canada
June 7 to 8, 2005

ACTIVE LEARNING THROUGH GROUP DIALOGUE IN A PROJECT-BASED COURSE ON ENVIRONMENTALLY ADAPTED PRODUCT DEVELOPMENT

M. Knutson Wedel[1], A. Boldizar[1], and J. Malmqvist[2]

1 Department of Materials and Manufacturing Technology, Chalmers University of Technology, 412 69 Gothenburg, Sweden

2 Department of Product and Production Development, Chalmers University of Technology, 412 69 Gothenburg, Sweden

ABSTRACT

This paper describes experiences of active learning through project based learning in combination with group dialogue between students. The learning approach was applied in an elective course about environmentally adapted design of products given by the Department of Materials and Manufacturing Technology for third and fourth year students. The aim was to implement more reflective teaching and learning, moving the focus from a procedural approach to reflection and conversation for gaining understanding and perception. The resultant course was created aiming for a comprehensive lifecycle perspective of the disciplinary knowledge on environmental adaptation as well as development of student competencies such as responsibility, creative thinking and group dialogue. Assessment was pursued by a combination of oral and written examination through project presentations. The evaluation of how these ideas turned out was based on our perception as course examiners, the work and reports produced by students and the results from student course surveys. The first general conclusion to be drawn was that this type of learning was perceived as very different for the students compared to earlier courses. Time during the first group dialogue session was needed to prepare students for such a new experience and by that adjust their expectations. The use of dialogue in combination with problem-based learning was found very useful in this course on the complex and dynamic field of sustainable technology. The students showed enthusiasm and performed well from an in-depth learning perspective, however, it was found that the larger degree of freedom needed to be met by a corresponding increase of feedback. It was also found that well defined assessable course objectives were very useful as a tool not only for specification of course goals and examination but also to give feed-back.

INTRODUCTION

Future engineers are expected to work in a highly dynamic society and industry where facts will change, be questioned and discussed. The consequence for engineering education has been to develop education with increased emphasis on "transferable" or "generic" competencies such as e.g. communication. Traditional and contemporary higher engineering education in Sweden have, however, since long been organised primarily for one-way communication, where the students are mainly "listeners-followers". Typically, a course consists of theoretical lectures in large classes, in combination

with recitals in classes of about 30 students. Some courses also include laboratory work in smaller groups. Finally, assessment has usually been based on a written exam. These formal teaching and assessment methods do not appeal to all students. Research on student learning has concluded that students have different orientations and learning styles. Entwistle, for instance, identified two dominant orientations called knowledge-seekers and understanding-seekers [1]. The former, searching for facts, are not interested in speculating or searching for deeper meaning. In contrast, the latter try to relate facts to earlier experiences and find connections and discrepancies. Traditional teaching as described above tends to favour knowledge-seekers and thus unintentionally encourage surface knowledge on the expense of deep knowledge.

Today, the traditional educational methods are therefore changing towards a pedagogical culture more focused on learning instead on teaching, where the students are taking more responsibility for their own learning [2]. In general, there is a growing interest in reflective teaching and learning, moving the focus from a procedural approach, ploughing throw coursework, to thoughts, reflections and conversation for gaining understanding and perception of the real world. Instead of stimulus and response, there should be insight and action [3]. In order to achieve this, communication between students and teachers and between students plays a key role. Technical knowledge and non-technical competencies such as communication are becoming interdependent. Engineering students need to learn communications' skills in the technical context as they represent ways to express and apply technical knowledge. Conversely, practicing the skills in the technical context allows students to acquire a deeper working knowledge of engineering fundamentals.

These insights have heavily influenced the educational framework developed by the CDIO Initiative which envisions an engineering education set in the context of Conceiving - Designing - Implementing - Operating engineering systems, hence the name CDIO [4-5]. A CDIO-based curriculum addresses the technical fundamentals of the particular program as well as a broad set of personal, interpersonal and product and system building competencies. This is achieved through requirements on the program to have a curriculum that is carefully designed to meet clearly stated learning objectives, a richness of design-build-test experiences, and feature integrated learning experiences where learning of professional competencies such as communication and teamwork are integrated into disciplinary and project-based courses. In these projects and courses, students are presented with problem-solving activities that incorporate authentic, real-life questions and issues in a format that encourages collaborative effort, dialogue with informed expert sources, and generalization to broader ideas and application.

In this paper we describe a project-based course which features a novel approach towards active experiential learning that enables and strengthens the inclusion of integrated learning of communications' competencies into the course. The main idea is that a strong emphasis on dialogue between students would promote learning of these competencies as well as creative thinking, particularly in the complex field of sustainable development and technology. This is achieved within the setting of a problem-based, project-organized course (PBL). PBL, strictly defined, is a well known method for enabling students to experience problems in real cases, gather the discipline-based knowledge as needed and to motivate students to an active search of further knowledge in dealing with problems at hand [2, 6-7]. An effective use of dialogue as defined by Olausson, Isaacs and Severin [8-10] within this context is then explored in order to provide integrated learning of e.g. communication within the problem-based course setting.

COURSE DESCRIPTION

Course data

The elective course "Environmentally adapted product development and manufacturing" has been taught from 2002 in the Department of Materials and Manufacturing Technology for students in their third or

fourth year. The course duration is seven weeks, corresponding to 7.5 ECTS credit units, and requires one faculty member as instructor per ten students. The number of students was thirteen the first year, and has then increased to twenty-five the following years. According to the general PBL approach, the students perform case studies in groups (project groups). The student team group size was initially six to eight students, changed to a maximum of five the following years to facilitate co-operation in terms of meeting schedules and dialogue. The basic open problem of the project is to redesign a product for environmental adaptation; especially concerning material selection and manufacturing methods. Examples of products for the projects are vacuum cleaner, hard disk, low-energy lamp, chain saw, refrigerator, cell phone, washing machine, and car tyres.

Learning objectives

The course is based on a life-cycle perspective and deals with adaptation for recyclability, environmentally adapted materials selection, alternative construction- and manufacturing methods and eco-labelling. All of this is focused on the project, expected to result in guidelines for design of a specific product, with special regard to environmental aspects. The learning objectives of the course were as follows.

After having completed the course, students are expected to:

- describe common assessment tools for environmentally adapted product development and make appropriate and motivated selections of tools
- describe the environmental influence of common engineering materials and to make motivated selections of materials
- have used the chosen assessment tools for analysis and then redesign of a product for environmental adaptation, especially concerning material selection and manufacturing method
- with supervision of a teacher made the necessary choices of course content and course literature in order to solve general tasks and formulate specific problems
- have been in contact with system thinking
- have improved their teamwork and communication competence
- have practised critical thinking and creativity

Learning approach

By using the PBL approach the obvious advantage is the use of the project work as a unique learning motivator. The students will also learn how to handle the uncertainty of a “real-life-like” situation and deal with open problems. At best the student might “learn the ability to confront the concrete details of real problems and to abstract a relevant understanding of them – to build ties between these problems and abstract concepts” as formulated by Cannon et al. [11]. An old saying is that we do never really understand the answer of a question we have not, on our own, genuinely asked.

On starting the course the students were given opportunities to present themselves and their personal learning expectations. Based on that, they were divided into heterogeneous groups formed by members with different main interest; e.g. production, materials or environment. A four-hour session was dedicated to introduction to problem-based learning, course objectives, dialogue and the CDIO project. The same week also three basic lectures were given; on lifecycle analysis and on metals and polymers from an environmental perspective. Time was also spent on dialogues for the students to get to learn each other in the newly formed groups and to focus on problem formulation connected to their cases. During the following six weeks learning was accomplished through project work. A study tour, for instance to a modern scrap-yard, was encouraged but not compulsory. Every week student groups and faculty met for a very student active four-hour session, where communication and the use of dialogue were in focus, see below.

Dialogue in teaching is not new, it is known from teaching in ancient history, e.g. Socrates. The meaning of the word dialogue in this paper is conferring to a documented method to both think and talk together in order to solve problems in a joint manner [8-10]. The idea in this course is that dialogue between students is an active method which promotes learning as well as creative thinking. In addition general competencies such as teamwork and communication would be enhanced. Dialogue thus plays a dual role as an educational as well as a problem-solving tool. In order to accomplish a good dialogue we explicitly teach how to use dialogue, which made dialogue a course objective the first year. A decision taken later, regarding proficiency levels, consider it a method to be used and not a goal in itself. An unexpected advantage was that it could be used for assessment, see below.

In figure 1 the difference between discussion and dialogue is outlined according to Olausson [8]. The general idea is to be aware that a misunderstanding or a difference in opinions leads to a choice. By avoiding debate or compromises and instead go into dialogue the conflict might be fruitful. The fundamental parts of a dialogue are to listen openly, await and then speak freely, at best elucidating the different person's perspective leading to something completely new, the highest in common. From a learning perspective it would enhance reflection and thus improve quality, depth and relevance of what they have learned.

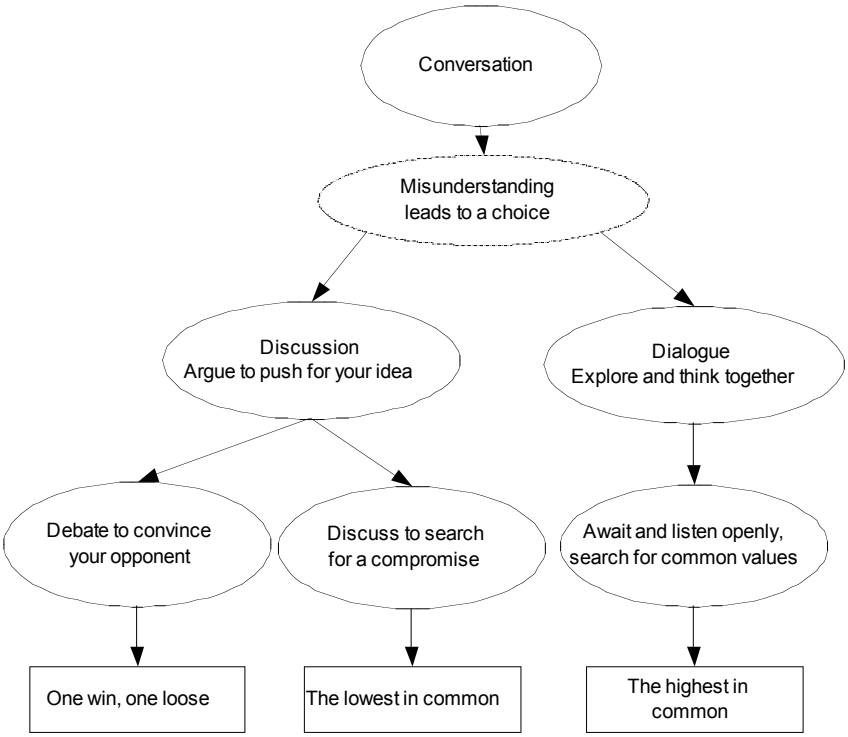

Figure 1: The difference between dialogue and discussion. From Olausson [8].

To realize dialogue within the course, the weekly four-hour sessions were planned but flexible. They consisted of student led presentations of about 5-10 minutes, one per group on relevant information for their specific projects, which were followed by group dialogues on the relevance of other group presentations to their own project. The session ended by a dialogue on the need for new information and on determining who should do the presentation the following week. In the meantime time was spent on discussions on how they had fulfilled the course objectives, planned group dialogues on reflection and more traditional tutoring of the groups. By planning for reflection and evaluation, the learning approach permits reflection in a Kolbian coil manner as described by the Cowan model [12]. He suggests three

planned reflections; *For*; to decide what the process will be to fulfil learning needs, *In* the middle to consider how the process has fulfilled the aims and *On* the learning process to decide what has been accomplished and what is lacking; with the aim of improving. Our approach permits reflection by dialogue through the iterative scheme, implemented every week, see figure 2:

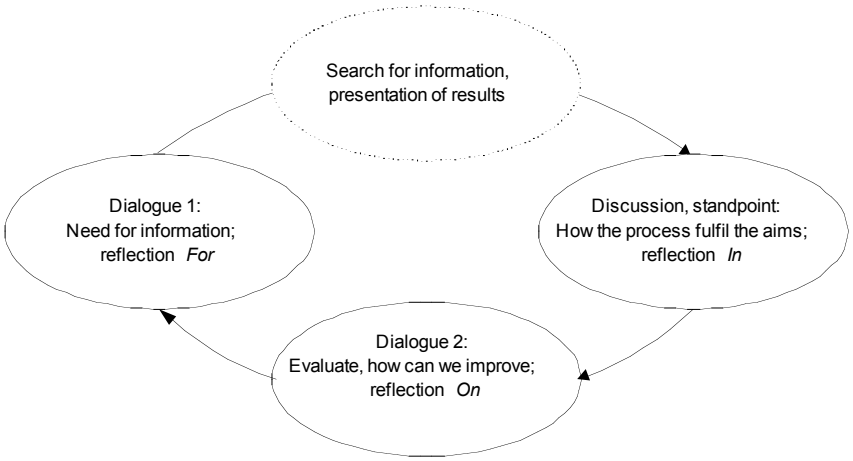

Figure 2: The iterative scheme of dialogue, which was implemented every week

Assessment

Assessment was made up of a combination of oral and written examination. To assess whether the course objectives were attained, they were displayed weekly with dates on accomplishment and checked. One method we found useful was letting students have a group dialogue on selection of e.g. tools for lifecycle analysis, listing them and be interviewed on the motivation behind the choices. To assess whether the course content and course literature choices were done by all, the demand was one presentation per student. The content of the presentations was assessed orally and in student reflections every week whether it was leading to fulfilment of the course objectives or not. The full course was concluded with a written report and presentation of the case studies, assessed traditionally by criticism of the oral presentation and report content and form. Guidelines were given in advance.

Based on assessment as described above, we found in almost all cases that the students performed very well and the reports were of a high quality. We also found that the large degree of freedom may result in a sense of insecurity, which might lead to some frustration. Even though "a search in the dark" could be beneficial from a learning point of view, the freedom has to some extent to be met by a rich and timely feedback every week. The course objectives were then actively used several times and feedback could be linked to them; giving a mix of feedback and assessment.

It may be worth noted that the assessment only resulted in a pass/non-pass examination. The main reason for this was our reluctance to grade individual work done in a group. There are numerous examples in literature, for instance by Gibson [13], listing possibilities such as peer rating sheets for team members to rate each other, criteria and rubrics for grading and plans for multiple assessment points. For the future that may be used for grading, but for the moment we concentrate on the course objectives as defining what we think they would need for the future, leaving no room for competition or increase of workload for one course.

DISCUSSION

In the course presented here the learning approach was composed of project based learning combined with dialogue. The evaluation on how this turned out is based on our perception as instructors and examiners, the work and reports produced by students and the results from student course surveys.

Student evaluation

Course surveys were performed mainly according to Ramsden's model [14]. The course experience questionnaire was used both at the mid-course evaluation at a discussion and at the end of course in written form. The five parts of the questionnaire related to the student opinions about and suggestions for improvements on the performance of faculty, learning objectives, work load, student responsibility and independence for learning and, in the final written evaluation, also about assessment. Some comments have turned up every year to a certain extent. The students are overwhelmingly positive and in general they identify the course as very different. They are satisfied with time for reflection at the same time as some of them want to give more presentations. Some interesting opinions on learning have been noted, such as:

- *"The learning was large compared to the workload, not 7.5 ECTS credit point's workload but 7.5 points learning!"*
- *"Mental preparation and thinking takes time"*
- *"I learned more compared to other courses"*

The students are less positive about the statement "teachers supply limits and clarity", year two almost half of the students did not agree. One might see that as an indicator to give more limits, on the other hand, it might be a good thing to let the students "search in the dark" for a while – to give time to formulate questions. Some opinions about lack of feedback was also stated, which is coupled to limits and freedom. Interestingly, the students that enjoy the freedom the most also wanted more feedback and limits. Apparently, the overall learning approach works out well from the student's point of view, but the balance between freedom and limits is crucial and regular feed-back is important for them to feel confident in this context. Concerning learning of the generic competencies, the students clearly state that they have developed in that sense, see table 1.

Table 1: Student opinion on the development of generic competencies.

To what extent did you develop:	**2002**			**2003**			**2004**		
More than (+) or less than (-) expected	+	0	-	+	0	-	+	0	-
System thinking	10		4	17	1	3	11	2	2
Ability for teamwork	12	2		20		1	14	1	
Communication	13	1		16	3	2	14	1	
Critical thinking	13		1	20	1		15		
Creativity	11		3	17	2	2	9	3	3

Faculty's reflection

The use of dialogue and problem-based learning was found useful in this course, dealing with the complex and dynamic field of environmental considerations, sustainable development and technology. As described, teaching was focused on getting the students forming their own representation of the material to be learned. The strong development within the field point also at the benefit of a learning approach aiming at student learning for a basically unknown future, since right or wrong will be shown in the future [2]. Compared to "traditional" teaching, where the instructor can seem to have control on the learning stuff on a detailed level, our students might pick up fewer details and concentrate on solving the problem as a whole. However, in a traditional situation, even if details are given from the educator, only a few

students actually learn, remember and grasp them [15]. Other benefits for a learning approach as described here are that it is easy to create an atmosphere where students enjoy learning and in addition to facts about environmental adaptation, they seemed to develop competencies useful for future engineering type of work, such as higher level thinking, trouble shooting, responsibility and teamwork.

It was noticed during the course that learning mainly seemed to be perceived by three sources; within themselves, from each other and by external information. Faculty was seen as a resource for guidance, more of a mental support for feedback rather than a source of information. The role we find is in agreement with the findings of Taylor et al. who shows that successful coaching encompasses three main responsibilities; *mentor* providing support by showing the way, being there, aware and helpful, *mediator* being buffer between external reviewers and customers and *manager* guiding the team in both team processes and the design process [16].

Another reflection to be made is of a more financial character; an upper limit of about 24-30 students for three faculty members, spending 20% of their time, seem to be realistic, which makes the course expensive in terms of faculty member time and the course thus cost about 10% more than the average course.

The learning approach from a gender point of view

More female students than average have chosen the course described here; over the four years there have been 42, 36, 25 and 37% female students compared to an average of about 15-20% in the programme as a whole. One might see this as an indication of a learning approach that is appealing for women. We have not asked our own students yet, but by a comparison to literature it seems that our thoughts of dialogue in combination with PBL would suit female students as well as male students. Gender-inclusive education is constructed to meet the needs and experiences of different students and an interaction characterized by respectful attitudes regardless of sex, age, study background or other traits [17]. It is also known that changes towards a more gender-inclusive education makes women thrive, but men flourish equally [18]. There have been some Swedish projects devoted to find out tendencies in female preferences regarding education [17-19]. A general conclusion was that a co-operative form of work is much appreciated, help to create a social environment different from the traditional academic setting, and also lead to a deeper conceptual understanding [18]. Some other things that seem to be important are a personal contact between faculty and student, feedback, learning assignments in touch with real life, comprehensive view in teaching, time planning in project work, assessment by production (e.g. a report) rather than reproduction (learning by heart) and the use of female role models.

Additionally, there may be a general tendency of female students spending more time than male students on group processes [18]. The implication for us would be that an individual assessment of group work based on both process and outcome may be better suited for female students.

CONCLUDING REMARKS

The first general conclusion to be drawn is that the learning approach seems to work out well, but we have to respect that this type of learning probably was perceived as very different for the students compared to earlier courses. Extensive time during the first session seems to be needed to prepare students for the new experience and by that adjust their expectations. During the annual course development we also maximized to small groups of 5-6 students in order to facilitate student group meetings and dialogue.

We also found that a large degree of freedom may result in a sense of insecurity, which might lead to some frustration. Even though “a search in the dark” could be beneficial from a learning point of view, the increased freedom in learning needs to be met by timely feedback. The learning objectives were

actively used several times during the course and feedback can be linked to them; giving a mix of feedback and assessment.

In this course, the students might avoid go into detail too much and instead concentrate on solving the problem as a whole. Statements in the course evaluation showed that students enjoyed learning and were learning about what they believed to be necessary for future workplaces, such as higher level thinking, trouble shooting, responsibility and teamwork.

It seems, based on the number of female students and a literature survey on gender and learning that the learning approach of PBL in combination with dialogue between students would appeal to female students.

ACKNOWLEDGEMENTS

We would like to express our gratitude to the Knut and Alice Wallenberg Foundation for financial support.

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