INNOVATIVE METHODS FOR ENTREPRENEURSHIP AND LEADERSHIP TEACHING IN CDIO-BASED ENGINEERING EDUCATION

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ABSTRACT

This paper focuses on mixed methods for teaching and learning; with special emphasis on individualized learning and engagement of students for reaching better results and relevance in CDIO (Conceiving, Designing, Implementing and Operating)-based engineering education. Four types of learning activities are discussed in the paper; “flipped classroom”, “experiential learning exercises”, “sharp live cases” and “theory-based practical exercises”. The empirical material consists of the authors’ own teaching experience. Based on a literature review and our own experience, we propose a model of components crucial to take into account when learning activities are designed and practiced. These components are stakeholders, pedagogics, technology and context.

KEYWORDS

Entrepreneurial learning, Flipped classroom, Blended learning, Live cases, Experiential learning, Standards: 7, 8, 10.

INTRODUCTION

One of the important intentions for development of CDIO (Conceiving, Designing, Implementing and Operating) was to re-include practical training into engineering programs. Currently, integration of topics such as entrepreneurship and leadership within CDIO-based engineering education is a challenging task for teachers, program leaders and coordinators.

At Linköping University, Department of management and engineering, we give courses in entrepreneurship and new venture development, innovation, organization, project management, marketing and business administration. Our courses are included in most of the engineering programs given at Linköping University, either as mandatory or elective, and engage about 2000 students on an annual basis. We also have extensive experience in designing courses with inclusion of a variety of learning activities. This variety is based on the premises that learning should be student focused and that students have varying individual learning preferences (i.e. four different learning styles: reflectors, theorists, pragmatists and activists; as described in Kolb 1984). Other premises are that relevance, passion and “the fun factor” enhance learning.

Alongside face-to-face traditional lecturing, we therefore work with a mix of tools and approaches to enhance student learning. In this paper, focus will be on four types of learning activities, i.e. sharp live cases (the term “sharp” implies here that the cases are real and on-going ventures striving for commercialisation, and not fictional cases created solely for educational purpose), experiential learning exercises, flipped classroom, and theory-based practical exercise material. These methods are useful for CDIO-based teaching and learning within our areas where development of skills, attitudes and making sense of context are integral parts of the learning process. The mix of methods is also advocated in several earlier studies. See e.g. Fayolle & Gailly (2008), Politis (2005) and Gibb (2002). This mix of methods enables learning of a wider range of skills and the integration of thinking, feeling, perceiving and behaving within the learning experience.

The aim of the paper is to describe the activities “Flipped classroom”, “Experiential learning exercises”, “Sharp live cases” and “Theory-based practical exercises” and share how they are used and combined in our courses. We will also discuss students’ experiences and results as well as experiences reported in the literature on entrepreneurial, experiential and blended learning.

METHOD

The research behind this paper is a combination of induction and deduction. The induction part is about the real-life experience of the authors, especially regarding different kinds of “educational experiments” over the years. Regarding deduction we have formed a frame of reference where various theories of mixed methods for learning are included. The creation of the model of crucial factors is then made by means of integration of deduction (theory) and induction (our own experiences).

LEARNING THEORIES – A SELECTION

People are different, think different, prefer different and have different abilities and solve problems in different ways. In the light of this human diversity we all learn in different ways (see e.g. Kolb, 1984). Some prefer to read alone in quiet rooms, others learn in groups through interaction and discussion. Some are active in the early mornings and others work late nights. Some want to combine different sources of knowledge, while others want one book. What is right and what is wrong cannot be told. At a university in the forefront, it is important to be able to meet people alongside their learning processes. This approach implies that several forms for learning need to be used and combined.

One buzzword describing this is the term “blended learning” which is frequently discussed in recent literature (see e.g. Garrison & Kanuka, 2004; Ginns & Ellis, 2007, or Lopez-Perez et al, 2011). According to Garrison & Kanuka (2004), the term blended learning, in its simplest form, is a mixture of traditional face-to-face learning and e-learning. However, it could, according to the authors, be made more complex than that. The key word is combination, and since there is a lack of a clear concept we will, from here, talk about mixed methods for learning.

Besides meeting with different learning styles, we believe that inspiration is a vital force to stimulate learning and curiosity. This is manifested in the second, out of five, principles for learning launched by MacInnis, Ramsden & Maconachie (2012); ”interest and explanation”,

i.e. to make the subject interesting and challenging to the students. However, for a teacher to be able to inspire, engagement is needed, which in turn calls for support and recognition also from the university. The fifth principle launched by the same authors is the importance of involving students. This factor is also put forward as a success factor within studies of blended learning. For example Garrison & Kanuka (2004) write: “What makes blended learning particularly effective is its ability to facilitate a community of inquiry ” (p. 97).

From a general educational point of view, there are different approaches to learning that often take place in a system with different levels of components. A traditional way of teaching is a lecture where the teacher teaches the student by means of some kind of “osmosis”. An example is reading out loud and the students strive to remember what the teacher says. According to this view, knowledge is seen as a product and the task of the teacher is to be a transmitter. According to Svedberg (2000), knowledge creation instead could be regarded as processual. Following this view, the teacher is seen as facilitator and the students as co-creators of knowledge, and the learner constructs her own learning. One example of a system supporting high-order learning is, according to Biggs (2003), “constructive alignment”, where the teacher should act as a catalyst and create a learning environment that supports learning effectiveness. The key to success is to align learning outcomes to all teaching activities. There are two major processes; first identifying intended learning outcomes (ILOs) and then choosing teaching/learning activities (TLAs). This could be illustrated through the traditional quote: “Give a fishing rod rather than a fish.”

Coupled to the above-illustrated perspectives on learning, teaching models such as “entrepreneurial learning” has been put forward. Entrepreneurial learning is, according to Politis (2005), synonymous with experimentation. Gibb (2002) also writes about entrepreneurial learning and demands for ”creative destruction” in order to create a more activity-based learning. Activity enhances involvement and thereby also engagement. Peirce argued already in 1878 that knowledge is not a product, but instead an activity (Peirce, 1878). According to Peirce, knowledge is created through doing things, not watching things being done. Dewey is recognized for his theory of knowledge development that departures from the idea that knowledge only could be obtained through action (Dewey, 1899).

The literature also suggests that practical appliance is needed to obtain deep understanding of a subject. Furthermore Whetten in 2007 wrote: ”Regarding higher level learning objectives, a common concern raised by teachers, especially those teaching particularly difficult subjects, is that students can’t apply something they don’t understand. Although this is true, it is also true that students achieve a deeper level of understanding when they are required to apply what they are learning” (Whetten, 2007, p. 345).

During recent years, another pedagogical buzzword has appeared, namely the so-called “flipped classroom” approach. Bergmann and Sams at Woodland Park are regarded as those who invented the concept “flipped classroom” 2007 (White, 2011). The concept implies that lectures are available for viewing by the students in their own time, while teacher-led learning occasions become more focused toward explanation and discussions of theories. According to Goodwin & Miller (2013) the teacher is regarded as a coach that identifies ILOs and guides the student to higher level of learning.

Flipped classroom has according to the research of Findlay-Thompson & Mombourquette (2013) both positive and negative sides. Using the flipped classroom it is therefore crucial that everyone involved understands and cooperates with the purpose and that teacher can create engagement within the group and use the full concept, not just launching some videos.

The flipped classroom approach can solve problems in case of pacing through enhancing self-paced learning that according to Hattie (2008) is one of the more important aspects of learning. The concept also focuses on student-teacher interaction by e.g. letting the teacher talk with the students instead of at them.

Irrespective of approach followed, we believe that mixed methods for learning is important when implementing CDIO into engineering education, primarily because it enhances learning of both knowledge, skills, and attitudes, which are central to the CDIO syllabus (Crawley et al, 2011). According to Lopez-Perez et al (2011), the mixture and combination of different methods for learning enhance motivation and creates a more positive attitude towards learning. Introduction of new kinds of subjects fits well into engineering education curricula and calls for varying methods of teaching that can stimulate student engagement and activity in the classroom.

RESULTS AND EXPERIENCES

Flipped classroom

The "flipped classroom" approach implies gaining of knowledge before class rather than in class, and this could be done in several ways. This is already practiced by many teachers, for example through seminars with mandatory readings. In courses at Linköping University, such as a basic course in industrial economics, there can be 240 students and using the flipped approach facilitates flexibility and ways to customization for every student's learning and their chances to perform their best. Electronic platforms are not the only tool that can be used, but are a convenient way to work with the flipped approach, as it enables interaction independently of time and space. Furthermore, students can be served a "smorgasbord" of readings, films and downloadable exercises dedicated to the different subjects of the course. Before participating in a classroom activity students can engage in prior assignments such as watching "trailers". This can create a common starting point. Instead of the teacher reading out loud, time in class can instead be used for focusing on joint problem solving. This creates possibilities for more learning during lectures which become interactive where teacher and students create the learning together. So-called beehives (discussions of given questions/problems in pairs) are used to let students in large classes interact simultaneously. Moreover, lectures can also be recorded, which creates possibilities for the student to learn after class through being able to repeat, relate, and reflect. Further comments following what happened in class can be provided by both teacher and students, using for example discussion forums.

Based on our experience we propose the following success factors regarding flipped classrooms:

- Careful plan based on three phases: before, during and after classroom activities.
- Crucial that everyone involved understands the purpose and concept of the three phases.
- Well-structured course material with instructions for preparation, e.g. structured following the different subjects treated in the course.
- The course material ought to be structured according to: "before-the learning occasion-activities", "during-the learning occasion-activities" and "after-the learning occasion-activities".

Experiential learning exercises

Experiential learning is based on exercises where students experience some kind of problem-solving, role-playing, or engage in some other kind of "doing". This kind of learning engages students and lets them be an active part of their own learning (NIU, 2012). Through experiential learning knowledge can be internalized in a more long-lasting way and skills and abilities can be trained and reflected upon.

Topics such as physics and chemistry often offer experiential learning in a lab setting. During courses in organization, entrepreneurship, innovation, marketing, and leadership experiential learning is less commonly used, but equally helpful if done in a structured way. We have successfully used various exercises in order to enhance our courses and integrate experiential learning (e.g. "the organization game", "paint book factory", "value creation forum"). These exercises start out with providing the students with a set of resources, specified prerequisites and rules, as well as an assignment. The goal is to simulate different real-life situations and let the students experience for themselves the relevance of theories and models presented in a course. After an exercise the students are given time to reflect, discuss and share their thoughts on what happened and why. A session ends with a summary of important learning points led by the teacher/instructor.

Based on our experience we propose the following success factors in experiential learning:

- The exercise should correspond to students' interests and has to clearly relate to other course content. This relation should be explicitly explained by the course leader.
- Every exercise should have a specific, narrow focus and a few selected learning points that it attempts to cover.
- The teacher/instructor needs to prepare a strategy for summing up students' insights in a structured way, e.g. a "board plan" similar to those used in case-based teaching.

Sharp live cases

For Linköping University relations and collaborations with industry and other external organizations are highly desirable. This is expressed in the policy for how the master of science programs in engineering should be run, i.e. that the education given should be relevant to industry. One way to address this is through using live cases in courses. Through collaborating with idea owners, the students are given a taste of the everyday life of entrepreneurs and idea owners. Lecturing is mixed with practical work, which results in a feasibility analysis for the new venture. The live cases are commonly (1) applied research projects aiming at commercial products, (2) independent inventor ideas or (3) non-core development ideas from established firms. They are recruited from our business networks. All of the cases are in an early phase of development. In some cases a company has been registered, but the majority are on project level.

When a course is started, the students form groups of approximately 5 persons. After this the live cases are briefly presented, and then distributed. Lectures and more practical and hands on workshops are given through the course in order to give tools for analysis. Here the lectures give the theoretically based tools, and the workshops give insights in how these tools could be used in practice. Throughout the course, the students interact with their idea owners and work on their analysis. They make presentations, where they get feedback. They also get coaching from teachers and business coaches. The fact that there is no "one and true answer" and that the idea owner struggles along with the students gives important

insights into the early stage entrepreneurial process. The fact that there is a stakeholder also calls for engagement.

From a recent evaluation of an entrepreneurship course held in the autumn of 2013 we got the following feedback comments: “Live cases are valuable”, “Live cases are good, but it is a bit problematic since we work with the idea owners’ babies”, “it’s useful to have something to apply the theories on” and “Nice that we were allowed to work with live cases, it gives anchoring and makes you feel that you can contribute.” When ranked by the students on a scale from 1 (not at all valuable) to 5 (very valuable) the mean value was 4.4.

Based on our experience we propose the following success factors regarding live cases:

- Choose ideas carefully and make sure to have a long-term planning since the process to find suitable ideas may take time. Too abstract ideas, or ideas that reside in a too early stage of development are commonly complicated to work with. Secure that the idea owner is willing to engage with the students and declare which learning objectives are focused.
- Strive to create awareness among the students that the ideas are “sharp”, i.e. real, not fictional, which means that both ideas and their owners ought to be treated with respect. It is also important to declare that learning, as opposed to consulting, is the main objective.

Theory-based practical exercises

Lectures on topics such as entrepreneurship commonly provide students with theoretical tools for analysis. However, we have recognized that students often have problems in implementing theories practically in their work. To address this problem, we have added dedicated workshops, where crucial theoretical tools and frameworks have been transformed into exercise material.

Examples are the Osterwalder and Pigneur business model creation framework “Business model canvas”, the SRI-international business concept tool NABC (Needs-Approach-Benefits-Competition), the classical Ansoff Product/market matrix, or the industry analysis tool “five force analysis” by Porter. We have also created our own tools such as a process for how to create and craft an elevator-pitch or a good presentation. The models are extracted and printed in A3-format and complemented with written instructions. Through lifting out frameworks and models for analysis on big sheets, the students are able to better implement theoretical models in their work. During teacher supported workshops exercises that include use of the models are introduced and supported by the teacher.

Based on our experience we propose the following success factors regarding theory-based practical exercises:

- Introduce the material when the workshop is started.
- Prepare written instructions so that students also can work on their own.
- Put references to theory at the course website so that students both can prepare ahead of the workshop and access further readings after the classroom activity.

ANALYSIS AND CONCLUDING DISCUSSION

The aim of this paper was to describe four innovative learning activities: “Flipped classroom”, “Experiential learning exercises”, “Sharp live cases” and “Theory-based practical exercises”

and to share how they are used and combined in our courses. We also aimed to discuss students' experiences and results as well as experiences reported in the literature related to blended learning approaches. In the light of learning theories and learning activities presented in this paper, we propose a model of crucial components for learning. See figure 1.

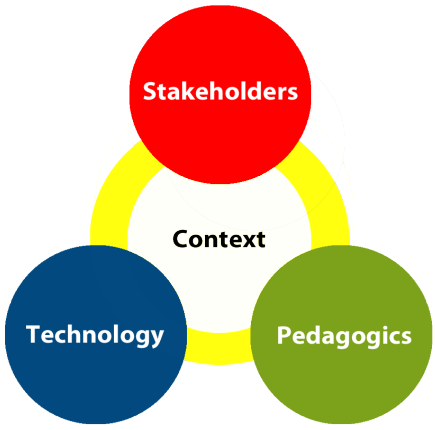

Figure 1. Crucial components for learning.

The model consists of four components that affect the learning outcome. The first component comprises the *Stakeholders*; i.e. all parties interesting in the learning situation, course or program. Here we take a wider perspective than e.g. Fayolle & Gailly (2008) that solely includes the audience in the model, and leave other type of stakeholders out. In our model, the parties are e.g. teachers/lecturers, students, and industry/future employers. Questions worth asking are: Who creates the learning? Who learns? What are the learning objectives/goals of the different stakeholders? What resources in case of course budgets, teachers, skills and desires are present?

The second component is *Pedagogics*; e.g. the key learning objectives, the pedagogical methods that can be used, and the inspiration-factor as suggested by McInnis et al (2012). The individualization factor put forward by several studies in general and Kolb (1984) in particular could be met through use of mixed methods, such as flipped classrooms, experiential learning and theory-based practical exercises. Questions worth asking in the pedagogical work are: How is the journey to reach the learning goals arranged? What methods can be used? What kind of preparation is needed by the stakeholders? The three phase model (see Figure 2) can be used when introducing new learning activities.

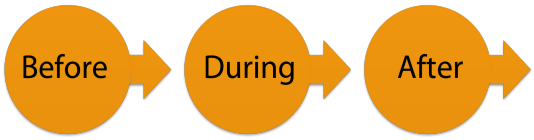

Figure 2. The three phases of learning: before, during and after classroom activities.

The third component is the utilization of *Technology*; e.g. the technology available and usable for the current learning situation. Technologies such as electronic platforms for learning and collaborating are often used in combination with flipped classroom approach. However, both benefits and obstacles following the use of technology for all stakeholders involved in knowledge co-creation are an important factor in this context.

The fourth component is the *Context* in which the learning takes place. Context is here defined as both the campus environment and places outside it such as companies and other organisations. In short it is the "expanded space" (in relation to only the physical classroom) where the learning is facilitated. We especially want to underline the places outside the university (external environment) towards which the theoretical as well as the practical learning is mirrored and corresponded. In a general learning context, and especially in a CDIO context, the relevance of the education for e.g. the industry is of importance. This commonly implies that not only theoretical knowledge, but also a practical understanding of how theories can be implemented is of importance. To obtain this, use of live cases can add important perspectives.

To summarize, when creating CDIO-based courses we suggest that teachers incorporate the four components of our model; Stakeholders, Pedagogics, Technology and Context. With these components as background, and within the frame of the resources available, a teaching plan can be developed. This teaching plan can then be divided into sub-plans such as e.g. case teaching plans for usage of cases or board plans for use of experience-based methods. The four learning activities described in this paper are all useful tools for enhancing learning in CDIO-based engineering education. However, they are more demanding, at least initially, for the involved teachers and instructors because they require careful preparation, as well as testing and adjusting to specific student groups. We recognize that there is a need for formal evaluations of learning effects following the activities described here in order to create a solid foundation for matching activities with specific learning goals and objectives and we look forward to future studies of these and other similar activities.

Finally, we are witnessing a paradigm shift in higher education, where the alternatives to traditional campus-based education are numerous and with internet in everybody's pocket, the possibilities to gather information are unlimited. Students, as a group become more heterogeneous and more and more of them are asking themselves "what's in it for me" before they engage in activities. Taken together, this implies that the traditional role of the teacher, as well as teaching methods, need to be discussed and developed. We believe that learning and knowledge are co-created and hence the role of the teacher still is crucial but needs to shift towards being a facilitator and a learning architect rather than the oracle. At Linköping University we have been integrating "sharpness" and co-creation in education for several years. But we have merely left the shores and are looking forward to the continuation of a great and inspiring journey.

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