ETALEE2017

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Exploring Teaching for Active Learning in Engineering Education
SDU, Odense, Denmark
May 23-24 2017

Book of Abstracts

SDU Cortex Lab

Sammen skaber vi morgendagens virksomheder

DTU Technical University of Denmark

Aalborg University Denmark

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VIA University College

Aarhus University School of Engineering

ETALEE 2017 Programme

Day 1	May 23	
09.00-09.45	Registration - coffee and tea	
09.45-09.55	Welcome	
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12.15-13.00	Lunch	
13.00-14.30	Parallel Hands-on/ Explore session	Active session 2
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14.50-16.10	**Active Poster session**	
16.20	**Bus transport to Odense Åfart**	
17.00-18.00	**Hans Christian Andersen on the River**	
19.00	Conference Dinner Restaurant Nordatlanten	

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How to educate the best Engineers?

Helle Rootzén, Professor, DTU Compute

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Learning as a dynamic practice

Lene Tanggaard Pedersen, Professor, Department of Communication and Psychology, AAU

Wednesday 12.00 - 13.00

Engineering Education seen from a ”Rocket Perspective”

Peter Madsen, RML Spacelab

Keynote: How to educate the best Engineers?

Helle Rootzén, Professor, DTU Compute

How do we educate the best engineers? Asking that question raises a lot of other questions: e.q. How do we find the balance between theory and practice? How much should we - as teachers - be responsible for "making learning happen"? Should we instead develop student driven learning? And how big a role should digital learning technology play? I believe that learning could be much more individualized, efficient and fun - and that we could benefit from using more e-learning, letting the students take much more responsibility for their own learning process, and combine it with coaching from teachers and people from industry.

Helle Rootzén is Professor in Learning Technology and Digitalization at the Technical University of Denmark. Has been head of DTU Compute from 2010-2015. Am working on learning technology, learning analytics, evidence in learning, learning objects, e-learning, and student based learning. Likes to look into the exponential future, leadership, statistics, big data, and diversity.

Keynote: Learning as a dynamic social Practice

Lene Tanggaard Pedersen, Professor, Department of Communication and Psychology, AAU

This key-note by Professor Lene Tanggaard addresses the need of a dynamic understanding of learning in education and beyond. Research into knowledge transfer has shown that transposing the knowledge acquired in a training course onto work is not without its problems. People discover that learning processes can be difficult and at times they can regress. Furthermore, there is a body of knowledge that does not lend itself to absorption or transfer via traditional teaching.

It is simply not enough to just fill up on the mental stock of knowledge in individuals and in organisations. We are in need of a more dynamic understanding of learning. Most of our new graduates are equipped with analytical skills, a flair for acquiring knowledge and a willingness to learn new things. Yet the fact is that we could exploit these excellent skills far more systematically than we currently do – and this is true of skills acquired in academic as well as other contexts. We know that formal education or teaching is often the best way to instil deep specialist knowledge. However, most jobs in both private and public spheres need employees with both breadth and depth of knowledge if they are to have the ability to expand the frontiers of current expertise. We know that most innovative companies typically look for the 'T-shaped' professional, one who posses-ses a depth of skills and the ability to apply him- or herself to other areas. Such employees have mastered their subject; but they are also keen to explore any chance for learning something new wherever possible. Working on this broader plane often requires other elements: networks, experience and practicality. And it demands the kind of apprenticeship in which depth is combined with breadth. Could we work with this thinking also in formal education and develop a more active and apprenticeship based kind of teaching? These are the questions addresses by Tanggaard in the present key-note.

Professor of Psychology in the Department of Communication and Psychology at the University of Aalborg, Denmark, where she serves as director of the QS-research group (30 members, VIP), advisor for several Ph.D.-students, Co-director of The International Centre for the Cultural Psychology of Creativity (ICCPC), and co-director of the Center for Qualitative Studies, a network of more than 90 professors and researchers concerned with methodology and development of new research tools (http://www.cqs.aau.dk/). She is regional editor of The International Journal of Qualitative Research in Education and co-editor of Psykologisk Pædagogisk Tidsskrift. Lene is the author of numerous books and articles, among those the book: Lær – effektiv talentudvikling og innovation.

Keynote: Engineering Education seen from a "Rocket Perspective"

Peter Madsen alias "Raket Madsen", RML Spacelab

"If the United States, Russia and China can make space rockets - so can we."

With this quote, it was possible for Peter Madsen to cross borders and break with traditional ideas about what is possible and not possible. By use of extreme innovation, vision and dynamics, he is now realising his dream. It's all about the incredible way to an incredible target. From having built the world's largest amateur submarine to the world's largest amateur-built spacecraft, and most recently the Space Lab, Peter Madsen entertains about his innovative work from creativity and drawings into reality.

He provides insight into the technical challenges and discusses the work in non- profit and open source projects in relation to watch for political and legal loopholes.

Peter Madsen is not without reason demanded all over the country. He always enjoys top marks for his lectures in which he inspires his listeners. Get an experience out of the ordinary - it's innovation, motivation, passion and inspiration for the class!

Peter Madsen – better known as Rocket Madsen – is the number one autodidactic rocket constructor in Denmark. Peter was one of the main drivers behind the successful launch into space of an amateur rocket, a project that was based on a small budget and a lot of work from dedicated volunteers. Peter is also the man behind the world's largest amateur-built submarine, Nautilus, 33 tons and 20 m long.

Former Danish Minister of Transport, Lars Barfod (K) said in an interview with Ingeniøren the following: "I don't know whether we need more people who want to send men into space in a self-built rocket but I know that people who set ambitious goals and subsequently do everything to reach them are greatly inspiring. We need more of such people in Denmark." Hopefully, Rocket Madsen may inspire engineering students and their teachers.

Abstracts/Papers
Hands-on Session 1
Tuesday 10.45 - 12.15

	Hands-on 1 Room 2.0.08	Hands-on 2 Room 3.1.16	Hands-on 3 Room 3.1.15	Hands-on 4 Room 3.0.02
	Gaming with Teaching Philosophies	The Global Goals for Sustainable Develop-ment in Engineering Education	How-to engage students to go the extra mile with course projects	Are we building a tower of Babel? Active learning in teaching about, for, though invention, innovation or entrepreneurship
Author(s)	Lars Bogø Jensen Birgitte L. Christiansen Claus T. Hansen	Christian Thuesen Joanna Geraldi	Claus Melvad et al.	Hanne Løje Steffen Sørensen Mette L. Thomassen Raijv V. Basalawmoit Morten Dahlgaard
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Gaming with Teaching Philosophies

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Keywords – Teaching philosophy, teaching and learning, communities of practice, gamification

ABSTRACT
Professional practice in general is to a large extent based on tacit knowledge (Schön 1983). For university teachers, tacit knowledge includes knowledge about what works – and what does not work – when teaching a specific group of students a specific subject matter in a specific context.

Making tacit knowledge explicit is important for at least two reasons: For the individual it may facilitate a more conscious linking of loose impressions and observations from own teaching practice to general principles of teaching and learning, thus enabling a more systematic interpretation and development of own teaching (Mcalpine and Weston 2002). It is also useful – if not necessary - for communication with others about teaching and learning, e.g. when peer coaching less experienced colleagues, or sharing experience and collaborating on teaching development with colleagues. Teaching Portfolios are a well-known means for the individual teacher to develop a reflective approach to own teaching practice and the underlying values and presumptions, including a process of making tacit knowledge explicit (Smith and Tillema 2006). However, we see a need for methods for sharing, discussing and developing teaching philosophies in a collective process. The perspectives of introducing such methods are to support a team-oriented approach to teaching and to strengthen communities of practice (Wenger 2008)/ communities of learning among teachers.

So how can we do this? The authors have conceived and designed a game to identify and clarify teachers' values, attitudes and preferences related to their teaching. The core element of the game is a deck of cards each with a statement about teaching and/or learning, e.g. "Students must learn to dare to fail and learn from their mistakes", "What I teach is what students learn", and "Blackboards are an overlooked method of teaching". While the statements do not give the "solution" to what good teaching practice is, their purpose is to start a personal reflection.

During the game, the players go through an individual reflection process leading to the selection of a number of cards with statements each player find relevant and important in relation to the question "What is good teaching?" These are then ranked and discussed in a group of players who are asked see if some consensus can be reached and explore if they can identify common approaches to teaching and learning. This consensus may different from the individual player's choices.

We have tested the game in different scenarios: as part of a training course for experienced teachers, in a study group for faculty members on university pedagogy, among teachers and students at a specific

education programme, among directors of Bachelor of Engineering programmes, and at an international conference. Based on our experiences, we have identified a number of possible scenarios where the game can be used:

- Participants in a teachers' training course. Purpose: to clarify and articulate own teaching philosophy.
- A team of teachers teaching the same course. Purpose: to reach consensus on ground principles.
- Teachers and students in a course or education program. Purpose: to clarify mutual expectations and roles.
- Across an educational institution: Purpose: to create and support an increased awareness and discussion of approaches to good teaching practice.

In cases where the game is played among colleagues who collaborate e.g. on teaching a course or coordinating an education programme, the process may also contribute to developing and strengthening the community of practice they are engaged in.

In the hands-on session, which is a revised version of a previous workshop, we will introduce the ideas and intentions of the game and guide the participants in playing the game. Ample time will be given for individual reflection and collective discussion of identified values and approaches to teaching and the general outcome of playing the game. At the end of the session, we will invite to a discussion of possible applications and use scenarios, and to suggestions of improvement of the game.

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The Global Goals for Sustainable Development in Engineering Education

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Type of contribution: hands-on

ABSTRACT

Keywords – SDGs, projects, role of engineering, purpose, motivation

History is full of examples of how engineers for good and bad have invented and implemented technologies, with consequence far beyond their imaginations. Think for instance on the development of the combustion engine which enabled a revolution in transport and individual mobility but at the same time contributed to CO2 emissions and thus global warming. Or digital technologies that through the internet and social media have created platforms for information sharing and identity building in a globalized world but at same time creates more polarized and post factual societies.

A recent study by across 11 countries conducted among 10,341 respondents finds that engineering indeed played a vital role in creating our past and will continue to play a critical role in shaping our future. While this finding mirrors the common understanding of engineering, the study points to a need to change the role of engineering from "inspire new innovations" to "solving the world's problems". (QEPrize 2015)

United Nations recently conceptualized crucial world's problems in the form of Sustainable Development Goals (SDGs) as illustrated in the following figure. The SDGs are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. (United Nations 2015). Today the goals are adopted by all 193 UN member states and explicitly addressed by more than 9,000 companies in 170 countries representing nearly every sector and size (Global Compact 2017). Despite its current widespread diffusion, continues support for the SDGs through science and education is of outmost importance in the actual realization of the goals by 2030 (UN-SG-SAB 2014).

This workshop targets the role of engineers as persons who solve societal challenges. It will facilitate a discussion and will share some approaches to address the following question: *"How could we embed SDGs in engineering education?"*

We do this through a workshop facilitated as a knowledge café where the participants collectively explore how could we embed SDGs in engineering education, through several educational practices across the learning journey of engineers. A 'Knowledge Café' "aims to provide an open and creative conversation on a topic of mutual interest to surface their collective knowledge, share ideas and insights, and gain a deeper understanding of the subject and the issues involved." (Wikipedia). Participants of a 'Knowledge Café' rotate in small groups across different 'stations', in each station the group will discuss a different aspect of the problem, in our case, how to embed SDGs in engineering education. Specifically we will explore practices to connect the SDGs to core educational activities: courses, extra curriculum projects, individual major pieces of work like master and bachelor thesis, the overall learning environment of the university. Following the collective discussion and wrap of the workshop, the authors present their experiences working with SDGs in teaching project management to engineering students.

Our findings from educating more than 500+ students is that the SDGs represent an outstanding tool to convey the importance of engineering and to create a sense of purpose that represent a key driver for motivation. It further it enables collaboration between various disciplines and stimulates personal reflections on "what legacy do I want to leave?" and "what projects should I engage in?"

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How-to engage students to go the extra mile with course project

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ABSTRACT
Inductive teaching, problem/project based learning, course projects, small and large classes.

Please indicate clearly the type of contribution you are submitting: _X_ hands-on, ___explore, ____poster.

Many engineering students in Denmark, opposed to other countries, select a particular education based on what they find interesting (DEA rapport 2013). Course projects try to enhance this motivation with real life problems which they can relate to. Motivation is not only the student's problem, but also a problem for the study programme. Research indicates that failure to connect course content to the real world contributes to students leaving science programmes (Seymour, 2000). Engineering studies are often focused on educating for the industry, so there are plenty of opportunities to address this.

Course projects are one such way, which requires the students to produce a solution to a real world problem. The method employed is also known as problem/project-based learning, and are one way to remind the students of their goal and even motivate students to go an extra mile. Teaching course projects inductively, the setup is to start the course presenting a real-world problem that the students are expected to solve during the course (Prince and Felder, 2007). Afterwards the course material is taught, linking towards this goal. Using the inductive approach, presenting the problem before the students know how to solve it, entices a feeling of progress towards their goal when in the class.

But course projects also have pitfalls to be aware of. Course projects can make the students uninterested in material that does not take them towards their goal. Some students will express displeasure about the time required to solve the projects and conflicts in the team might occur. If the setup allows, some students might also try to split the work so strictly that each will only learn the fraction of the course material necessary to complete their part of the project. How to possibly avoid these pitfalls is one of the topics of the workshop.

Student feedback is generally positive, where some students dislike how open the projects can be. On the other hand in some course project the students go the extra mile. What makes the difference is one of the topics of the workshop. Students report that a course project has the ability to force them in a good way to apply what they learned and revise it along the way. Many express that the course projects were what really made them understand the curriculum. Also, one doesn't have to answer the question: "What is it for?" quite as often.

In this workshop the authors will each present their set-ups for course projects and experiences from working with problem/project based learning. The results of the method can be evaluated using student feedback and examples of learning outcome will also be presented at the workshop.
Afterwards we will split the workshop into three groups and share knowledge using a jigsaw method (jigsaw.org, 2016).

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Are we building at tower of Babel? Active learning in teaching about, for, through invention, innovation or entrepreneurship

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ABSTRACT

Keywords - Active Learning, Entrepreneurship Education, Innovation, Invention, CDIO

Please indicate clearly the type of contribution you are submitting: _X__ hands-on, ___explore, ____poster.

Background and explanation

There is an increasing trend in the use of "Active Learning" in engineering education (de Graaff *et al.* 2004), moving towards a "learner-centered" model from a more passive "teacher-centered" one. There has also been, in parallel, an increase in educating through/in innovation **and** entrepreneurship with an emphasis to encourage engineering students to develop competences through experience based learning designs (Xia *et al.* 2016). Indeed, the establishment of entrepreneurship education programmes in engineering education are a testimony to this trend. Active learning methodologies are widely adopted in entrepreneurship education. How to balance entrepreneurship education in education "about", "for" or "through" entrepreneurship is however still debated (Heionen & Hytti, 2010; Taru & Juha, 2016). Increasing demands for skilled engineers who can develop new solutions through invention and innovation have pushed universities to meet this demand from industry and society at large, which in turn have led to a plethora of entrepreneurship programs being developed within Engineering Education – some more hastily than others (Spee & Basaiawmoit, 2016; Maddock, 2013). These programs have either an implicit or explicit focus on developing student competences within invention, innovation and entrepreneurship without having clear demarcations of these concepts within the frame of program design (Toner & Tompkins, 2008). However, are we creating a "Tower of Babel" in the building of such programs without taking into account the fundamental differences and overlaps between invention, innovation and entrepreneurship?

With our workshop and the following “work-in-progress” paper we aim to answer this question and detangle the usage of these terms in the framing of education programs within engineering education. Furthermore, we use the CDIO framework (Crawley *et al.* 2011) as a guide to understand active learning methods within educational designs to understand the place of invention, innovation and entrepreneurship in engineering education program design. With the use of cases, anecdotes and theoretical references, a paper will be developed with the aim of recommending a broadly accepted language framework to design new engineering education programs for invention, innovation and entrepreneurship.

Set-up

At the hands-on session the participants will be divided into smaller groups and be introduced to the CDIO framework. Each group will have time to discuss the framing of entrepreneurship education programs within engineering education based on their own knowledge/experience. There will be two rounds where the participants will discuss in groups. The first round will have focus on “definition” and “context” usage of the participants using innovation, invention and entrepreneurship in their own programs. In the second round the participants will discuss CDIO as an educational framework and how they work with the four CDIO elements in their learning designs. At the end of the session, the groups will present a sum up of their discussions.

In each group one of the authors will be present to collect information. At the end of the session the authors will present their work and results so far and sum up on the results from the hands on session.

Expected outcomes

The expected outcome from the hands on session is more knowledge on how framing of entrepreneurship and innovation education programs is done within different engineering educations, which will be included in a recommendation for a language framework to design new engineering education programs. We also expect to use the knowledge gained together with our own empirical data and combine them into a journal article that would be then shared with the participants but also with the engineering education community at large.

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Abstracts/Papers
Explore Session 1
Tuesday 10.45 - 12.15

	Explore "Yellow Room"
	1: Death by x and y - a mathematicians lament 2: Experiences from a calculus class on using videos with interactive element 3: Benefits of using podcasts as supplementary teaching material
Author(s)	1: Per Skafte Hansen 2: Henrik Skov Midtiby 3: Reynir Smari Atlason
Chair	Regner B. Hessellund

Death by x and y – a mathematician's lament

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Dedicated to class 2.F of 2010-11

ABSTRACT
The Micro Project is a project assignment to small groups of learners, the outcome of which is an oral presentation (per group) attended by the other groups who supply constructive criticism. In mathematics, at least, it thus departs from the traditional book + lecture + exercise paradigm, which is known to stultify reflection, thus causing the mental 'death by x and y' mentioned in the title. Our collective failure to provide stimuli of mathematical reflection may form part of the cause of The Mathematics Problem, students' inadequate grasp of the mathematics they are assumed to master as they enter university. The Micro Project and experiences with its use in secondary education is described. Various challenges of carrying it over to tertiary education are listed along with suggestions as to how these can be (partially) met.

Keywords – action learning, micro project, mathematics teaching

I INTRODUCTION

It is possible to identify at least three separate, if interacting, sources of motivation leading to the musings of this paper:

- The Mathematics Problem – the gap between the mathematical skills university students are, often tacitly, assumed to possess and those they actually acquire during their years in primary and secondary school
- One sorely neglected thread in the web of reasons behind the Mathematics Problem, namely that we teach mathematics in the wrong way, or at least with an unfortunate bias
- The concept of action learning and one particular realization of it, called Micro Projects for want of a better name – which may to some extent help setting the pedagogical balance right as far as the teaching of mathematics is concerned

All three will be discussed in the following; but emphasis will be on the Micro Projects and the experiences the author had in developing and implementing them. By way of conclusion, the paper offers some reflections on the challenges meeting anyone who attempts to carry Micro Projects from their original setting in classroom teaching in the Gymnasium (the Danish version of High School) to university teaching.

II The Mathematics Problem

A very substantial literature exists on what has become known as *The Mathematics Problem*, and this is not the place to attempt a serious summary. An informal discussion of selected papers can be found in [12] (Danish) from which we can borrow the following, sufficient for our present purpose.

The Mathematics Problem, very tersely described, consists in the undeniable fact that students arrive at tertiary education – including university education – with an inadequate training in mathematics. This is sometimes seen as a recent or local challenge and various simple explanations and quick remedies are offered; but in fact, a glance at the literature (as in [12]) will convince anyone with an open mind that:

- The problem is 30-40 years old
- The problem is international
- The problem is truly complex as must indeed its reasons be

Of the many individual causes identified by various writers one can mention

- Inadequate planning within and between primary and secondary school
- Inadequate focus on/handling of the Transition Problem, i.e. the fact that a young person going to university experiences a complete change of environment and in fact of life conditions
- Too little focus on new teaching methods, especially those making use of the computer
- Too much focus on new teaching methods, especially those making use of the computer (-!-)

At least a dozen such observations or claims are made in the serious literature on the problem – with several more in the popular press (many of them uninformed and groundless, but persistent).

It is clear, or so the author thinks, that none of these alleged causes can be held solely responsible for The Mathematics Problem but that they must be seen as interacting. But one possible such element is hardly ever discussed – although it is certainly brought up elsewhere, as the next section will attempt to demonstrate – namely that we may very well be teaching mathematics in the wrong way, not merely in terms of what we focus on, but in the entire conceptualization of mathematics as a subject to be learned.

III Do we teach mathematics with our eyes closed?

There is a wonderful observation ascribed to Pafnuty Chebyshev (-), se e.g. http://www-groups.dcs.st-and.ac.uk/~history/Quotations/Chebyshev.html

- To isolate mathematics from the practical demands of the sciences is to invite the sterility of a cow shut away from the bulls

A modern-day Chebyshev, Vladimir Arnol'd, voices a similar opinion in the opening lines of (Arnol'd, V. I. [3]):

- Mathematics is a part of physics. Physics is an experimental science, a part of natural science. Mathematics is the part of physics where experiments are cheap

Arnol'd goes on to criticize the increasing preoccupation with abstraction. Although he is mainly concerned with mathematics at a higher level than that encountered by, say, first year engineering students, he does in fact describe his own - inimitable – experiences with teaching secondary level pupils.

Yet, although there are many wonderful exceptions, many – possibly most – text books used in first-year university mathematics courses contain endless arrays of sterile exercises and no practical examples, no attempts to connect the calculations to the reality known to, and inhabited by, the students.

Even the 1119-page *International Handbook of Mathematics Education* (Clements [8]) devotes only one chapter to mathematical modelling, and a rather dry one at that. In fairness, it should be added that it does indeed have headlines such as Applicable Mathematics and Modelling for All and ensuing discussions, yet it seems – as far as the present author has managed to delve into it – to accept *status quo*.

So, there is a very real danger that a very large percentage of school children and 1st year students will be left with the impression that mathematics is "something to do with solving equations where you have to isolate *x*".

As for the gradual suppression of 'applied' mathematics in favour of the 'pure' version, the reader should consult (Maddy [15]). And to avoid painting too gloomy a picture: a collection of cases that actually provides some of what is here wished for can be found in e.g. (Sriraman et al [17])

But there is still more to this, as expressed by e.g. (Klamkin [13])

- I have thought for a long time that one of the most important goals of education is to get the students to 'think for themselves'. As I look over the American education scene, it seems that each year more and more material is being crowded into the curriculum. The net result being that most students hardly have any time to sit back and think out various problems for themselves. Consequently, most students will ***just parrot back*** the material from their texts or from their classroom notes

(Present author's emphasis, no offense to *psittacines* intended). A common observation along the same lines is voiced in (Bruckheimer and Gowar [7])

- The traditional emphasis is on technique as an end in itself; on gaining technical facility because that is what is wanted in examinations

An even deeper criticism is that we teach the isolated skills and leave it to the students to work out the big picture themselves – despite the recurrent emphasis of "the beauty of mathematics", *vide* Hardy.

It would be preposterous to suggest some simple remedy or other; but the next section describes what the author once did and hopes to do again, *mutatis mutandis*.

IV Micro-projects

The briefest of autobiographic sketches will provide the necessary background for the description to follow:

Author's note: After graduating as an M. Sc. Eng. in 1983, I was employed by the Technical University of Denmark (DTU) to write a text book on Linear Algebra. I next served as a research assistant at the Dept. of Mathematics, Univ. of Dundee 1984-1988, where during 1987 I also taught numerical solution of ordinary differential equations. Returning to DTU in 1988, I engaged in teaching of, and research in, Graphical Communication, Computer Graphics, programming, Numerical Analysis and various applications of mathematics. Leaving DTU in 2003, I was first employed at the Dept. of Education of the Danish Bankers' Association, where I served as a project manager responsible for an LMS while also developing an e-learning course in mathematics covering the Danish C-level (essentially 10th grade). After 4½ years at NeoConsult Aps., an IT company, as advisor and responsible for HRD, I returned to the world of education, serving as a teacher of mathematics and physics at Lyngby HTX (Danish "Teknisk Gymnasium") while also maintaining a secondary job as a mathematics tutor at DTU before returning full time to DTU primo 2014. End of note.

While at HTX, which educates 10-12th graders, emphasizing technical (and other practical) applications of most disciplines, the author felt compelled to develop modes of presenting mathematical material in a manner transcending the format of conventional exercises. One such was given the category name of *Micro Projects*. It was clearly inspired by earlier work on *action learning*, carried out at the Danish Bankers' Association and documented in (Hansen [11]), with roots further back in the teaching of Graphical Communication at DTU.

A Micro Project can in various ways be distinguished from conventional project assignments:

The class is subdivided into groups of (typically) 3-4 participants, each given a worksheet defining the task they must carry out. There is a common overarching subject, but each group works on a specific topic extracted from this subject. The goal is not a written report but an oral presentation. On the day of presentation, one group at a time is asked to explain its topic to the other groups, receiving immediate feedback in the form of (constructive) criticism from the audience. Typically, one other group is assigned the leading role as examiners. The teacher – the "grumpy corner" – will provide both the facilitation and a few extra comments in case *vox populi* has overlooked something.

A total of 24 Micro Projects in mathematics were planned, 8 per grade. (Similarly, 16 were planned for 10th and 11th grade physics). Of these, 17 reached the point where all ideas and material were collected, but only 6 were executed, as the author left HTX before the remainder could be carried through. (Of the Micro Projects in physics, 6 were executed, bringing the total of practical experiences with the form to 12, some repeated).

Many of the Micro Projects stayed close to the mathematical subject and were thus glorified exercises, albeit in the theory, rather than the calculations, pertaining to the subject. Yet, as it became clear that the pupils were easily capable of handling complex assignments, ambitions grew. Also, subjects first treated in project assignments were considered for a switch to this more liberal – and often very entertaining – format.

A full list of the subjects and their sub-topics can be made available to any interested reader. Here, two examples are listed in compact form and a further three discussed in more detail below:

Under the heading "Differentiation", the groups would have been asked to present the topics: 1) Curvature 2) Jounce 3) Taylor's theorem 4) Implicit functions (including the concept of a contour line) 5) The logarithmic derivative 6) Numerical differentiation 7) Splines and 8) Fractional calculus

(As for the latter, it was first made the topic of a project assignment and as such turned out quite successful despite its being rather advanced). This Micro Project was intended for a 12th grade class, but the author left HTX before the appropriate theory had been taught to this class.

In physics, under the heading "Pressure" the groups presented their work on: 1) The pressure under the feet of various animals 2) A pressure boiler 3) A lemon squeezer 4) The bubble 5) The paper ball 6) The diver's bell 7) The scroll pump 8) The siphon

This latter Micro Project was in fact implemented more than once and showed the ingenuity of the pupils when it came to the use of media such as short film clips, animations and various kinds of acting or role playing

Among the mathematical Micro Projects, we can take a closer look at: the first attempt; a failure; and a success:

The very first Micro Project was assigned to class 2.F of 2010-11 shortly after their first introduction to integral calculus. 2.F, a mathematics-biochemistry class, was small – hence only four sub-topics were needed – and with a wonderful social coherence that made it safe to try out this experiment.

The four topics were: 1) The areas of circular and elliptic annuli 2) Integration of Chebyshev polynomials 3) Various aspects of partial integration as exemplified by antiderivatives of $x \cdot \cos(x)$ and related functions; and 4) The concept of an integral with a variable limit

Altogether, the experiment was a success, although the pupils indicated quite clearly that this way of working was new to them. A fair amount of guidance had to be provided to make the class understand that this was not an assignment of the ordinary kind, i.e. they were not supposed to present a sequence of calculations but rather to attempt to make their new insight clear to each other. We can let this be

- Lesson 1a: Even when the format is radically different from well-known – and therefore “safe” – modes of learning, a tendency prevails among learners to attempt to squeeze this new mode into better known work patterns
- Lesson 1b: The author had in fact expected that something akin to the Micro Project was very familiar to the pupils from their primary school – but this may have been an ill-founded assumption

The Micro Project soon established itself as a useful way of regularly handing the initiative to the pupils, so when the author took over a Design-Technology class, an attempt was made to introduce vectors and their relations to other mathematical concept via cartography. A selection of mapping projections was made (Mercator’s, equi-rectangular, Gall-Peters’, sinusoidal, Kavrayskiy’s, Aitoff’s, Albers’, Lambert’s and stereographic projection), one given to each team; and the teams were invited to visualize the mechanism and illustrate and discuss the pros and cons of each of these. The necessary tools were made available to them and the work sheets provided links to more information. (This feature became regular when, in the early days, a pupil declared “I couldn’t find anything about it on the Internet”. This was quoted, along with the observation that this is equivalent to saying “I was late because the sun didn’t rise at its usual time”. Links were provided to English, German and French sources).

The cartography Micro Project was an abysmal failure.

To this day, the author refuses to blame the result on the Micro Project itself, especially since one team actually produced a fine presentation. – But the remaining teams either did not show up or 2 members appeared, claiming that the other 2 had the result of their work – or simply declared that they had not looked at the material. The author later learned that this particular class had a long history of absenteeism, lack of motivation and even a rebellious attitude to the effect that they didn’t want to learn this, that or the other.

- Lesson 2a: Micro Projects are not miracle cures
- Lesson 2b: Before implementing a Micro Project make sure the learners are ready for it

And to this section on an optimistic note:

A large class (31 pupils) of 10th graders were given a Micro Project on the subject of Extensions of the Number Concept. The sub-topics were

- Numeralia (including e.g. positional notation)
- Spoken words representing numbers (the author habitually asks whether “sytten hundrede og to og halvtreds” is a particularly logical rendering of 1752)

- Fractions, including continued fractions
- The elementary operations of arithmetic with a glance to e.g. the abacus and the *Pascaline*, an early calculating machine
- Algebraic numbers, up to and including the non-solvability of quantic equations in radicals (without proofs…)
- Binary arithmetic
- Matrices
- Complex numbers

It should be added that the worksheets explicitly demanded of the pupils that they identified and discussed at least two questions in addition to those mentioned in the description of the sub-topic.

The result was astonishing. Each group had fearlessly tackled its assignment and gave a presentation that belied the fact that these pupils had only just started their secondary education – some of them were 15 years of age, i.e. children, however much they disapproved of that label.

- Lesson 3a: If you ask the right question, all you must do next is step aside
- Lesson 3b: The amount of talent "out there" is overwhelming

Altogether, developing and facilitating Micro Projects in a school setting was a rewarding experience; but the reader should be warned that the amount of work is considerable.

V Whither Micro Projects?

It would seem reasonable to attempt to implement Micro Projects in a university setting, but the following issues must be taken into consideration:

- Classes in elementary mathematics are large, often consisting of more than 100 students
- The time allotted to the presentation of background theory of individual topics may be inadequate – for instance, the author currently teaches Oscillation Theory in the span of three weeks
- Although politicians and top managers may be enthusiastic and individual teachers willing to do the work, a peculiar resistance of the "not in my back yard"-type may be encountered from middle managers

As for the first of these, it is a resource question. So far, the author has only been able to rescue the idea of *Contextualization-Decontextualization-Recontextualization* – this choice of wording is taken from (Hansen. H.C. [9]) – by insisting that exercises should not be about "*x* and *y*" throughout, but should instead move to authentic models as fast as possible.

Examples: The Hydrological Cycle as source of linear systems (Rose, S. E [16]); Tuned Mass Dampers providing systems of differential equations ([1] Abdelraheem Farghaly, A); Annual variation of radon levels to be treated with least square methods (Arvela, H., O. Holmgren and P. Hänninen [4]); Traces cut by CNC-machines providing nonlinear equations (LIU Qiang*, LIU Huan, and YUAN Songmei [14]); and many others, even if many of these must be watered down.

The second bullet point above harkens back to the observation by Klamkin, op. cit.: We are forced to squeeze a large curriculum into a narrow time frame. It must therefore be emphasized:

The problem of time allocation is much exacerbated by the fact that we cannot expect the students to master the algebra of the solution processes needed to handle interesting challenges — in other words by The Mathematics Problem

As for the third, which was observed and discussed – but not analyzed or documented – in the EDU-IT project of 1999-2000 (reports are now scattered, but see (Hansen [10])), it is neither mathematical nor pedagogical in nature, yet has a considerable influence on education. It deserves further study, and the interested reader may want to consult (Askling, B and B. Stensaker [5]) or (Blackmore, P. and R. Blackwell [6])

There is still the possibility of introducing the Micro Project in 4th term courses or later, where classes are smaller and the curriculum somewhat more flexible. The present author hopes to be able to report on this in the not-too-distant future.

VI By way of conclusion

Without necessarily accepting the full eight-leaved *competency rose* of (Anonymous [2]), one may at least be allowed to wish for a balanced acquisition of

- Insight into the architecture of mathematics
- Competency in the handling of mathematical models
- Skills in the necessary calculations

Calculational skills can only be acquired by training via exercises. These are the mathematical equivalent of the pianist's scales and arpeggios. But no one would practice endlessly on c-minor scales in parallel sixths or the like without ever playing a real composition and at least hearing a recital or a concert. Likewise, an overdose of calculation without the least reference to either the physical reality or the bigger picture – and preferably both – leads to a Plato's Cave-like idea of what mathematics is about.

By focusing too much on these almost mechanical skills – which we cannot do without but which are not the essence of what we try to teach – we have become dispensers of sterile occupational therapy, merchants of death by x and y.

We need a lot of alternative ways of presenting our discipline. The Micro Project and the experiences it brought with it is but one of many possible such. Although a bit exaggerated, one may paraphrase Cato the Elder:

PRAETEREA CENSEO EXERCITIONEM ARITHMETICAM ESSE PRAETERMITTENDAM

and take it from there.

Acknowledgements

I would like to thank class 2.F of 2010-11 for providing the inspiration and the high spirited environment that made possible the first experiments with Micro Projects. – And mag. art. Helle Gjellerup for translating "Besides, I think number gymnastics should be abolished" into Latin. —

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Experiences from a calculus class on using videos with interactive elements

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ABSTRACT
Keywords – flipped learning, calculus, videos
Please indicate clearly the type of contribution you are submitting: **explore**

I Background

Calculus is a central part of the engineering educations at the University of Southern Denmark and many students find the calculus course challenging. During a calculus class in fall 2016, I experimented with using videos as part of the students preparation for lectures, as part of a flipped classroom. The videos focused on doing worked examples. In addition most of the videos were augmented with mini quizzes. In the mini quizzes students were encouraged to complete intermediate calculations at certain moments in the video.

II Explanation

The focus on worked examples in the videos, is based on my wish to build a scaffold for the students, to which they can relate new information they get from their textbook and the lecture. By providing a scaffold through a worked example, the students become aware of the terminology of the topic and have seen some of the central operations related to the topic. In addition the videos provide concrete examples of the subject that will be dealt with in the lecture, which is an effective study method according to (Rawson 2015). The addition of interactive elements to videos, is expected to change the video viewing experience from a passive viewing experience to an active viewing / calculating experience when interacting with the videos. Through this change of the videos, the learning outcome of the videos is expected to raise, as videos without mini quizzes often target the two lowest layers (remembering and understanding) in Blooms taxonomy, but videos with mini quizzes targets the third and fourth layer (applying and analyzing) in Blooms taxonomy (Krathwohl 2002).

III Set-up

Prior to each lecture the students were given a “weekly note” as a pdf file. On the weekly note there were suggestions for different activities that could prepare the students for the lecture. The activities were to watch one or more videos and some reading in the textbook. The videos were mentioned before the textbook to encourage the students to first watch a video and then read in the textbook. The videos were focused on problem solving (e.g. solve three linear equations with three unknowns) and not directly on introducing new theory. The intention were to let the students become familiar with the methods before digging deeper into the theory. In addition most of the videos were augmented with mini quizzes, where students were asked to answer two different types of questions. Either they had to calculate some intermediate results required for solving the current case problem or they had to choose a suitable strategy (from a list of possible strategies) for a certain problem. In practice the videos were added to a course on http://tekvideo.sdu.dk and then augmented with the mini quizzes. The augmentation consisted of adding question boxes to show at certain timestamps when playing the video. To follow up on the intervention, students answered a questionnaire about the usage of videos as part of the calculus course.

IV Results

The students highly appreciates the use of videos for their preparations and states that it helps them learn calculus. Some mention that it becomes easier to understand the textbook after having seen a video of a worked example. The use of mini quizzes in the videos shows that many students use them actively to test their knowledge. The number of views for each video that was included in the weekly notes were roughly viewed 1.5 time for each active student in the class. About 50% of the posed questions in the videos were answered.

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Benefits of using podcasts as supplementary teaching material

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ABSTRACT

In a multidisciplinary class, it is difficult to avoid covering a topic a group of students have already encountered previously. To avoid this, supplementary material can be provided to students. By doing this, the teacher can engage directly into deeper theoretical or practical work and minimize amount of time covering introductory material. It was the intent of this study to develop teaching material for students which could be studied while riding bicycles. This was achieved by recording podcasts where pre-requisite material was covered in a popular manner, allowing students to listen to the recordings through mobile phones while riding bicycles. By doing so, students can avoid investing primary time into learning, but could use time that was already spent on activities. Four recordings were made, ranging in length between 10 to 18 minutes. The recordings are then made available to students through an online platform, accessible through mobile devices. It was found that students who did not have the most suitable background found their understanding of the material to increase if the Podcasts had been listened to.

Keywords – Podcasts; Flipped learning; E-learning

I INTRODUCTION

In a multidisciplinary class, it may prove difficult to avoid introduction of material trivial to some, or many participants. One method to address this is to provide relevant reading material to students who lack the relevant background. Doing so does however increase the workload of those students which becomes unproportioned with regards to other students. Another way is to provide the students with video material to be viewed in their free time. Videos do however require the student to dedicate equal amount of time to them as they are long. The ideal situation would allow the student to get acquainted with the missing material without feeling that the workload is increased. The same situation should avoid prime-time being invested in the process of learning the missing material. In order to continue with such discussion, a qualitative assessment of time is needed. We can state that Saturday evenings are valued highly by most, while Tuesday afternoons are perhaps valued less. One also needs to take into consideration what is being done during the time. If one is conversing with a leader of the free-world, the time is valued higher than the time used for cleaning ones apartment. We would therefore like to provide a platform for students to invest non-prime time to the learning. Podcasts can be seen as a suitable way to accomplish this. Podcasts are much like radio shows. The only difference is that they are accessible on the internet and are generally not broadcasted live. The listener can therefore choose when he listens to the show. One way to listen to Podcasts is when the listener is commuting. This allow the listener to invest a non-prime time into getting acquainted with the material at hand. This paper focuses on this feature, where introductory material was recorded in a Podcast format for commuting students to listen to.

The class under study consists mainly of engineers with two types of backgrounds, a) Environmental engineering, and b) Product development and Innovation (PDI). Environmental engineers do have a background in various environmental assessments, while product development engineers generally do not. Introductory material to environmental assessments therefore needs to be given to PDI engineers, material that can in some cases be trivial to environmental engineers. In this paper, the aim is to provide introductory material through alternative online means. The research question addressed in this study is therefore:

a) Are podcasts a suitable method for delivering introductory material in a multi-disciplinary class?

b) Do students find themselves gaining content understanding using non-traditional methods of educational content delivery?

Using conventional flipped learning methods, where videos are recorded require students to use primary time watching the computer screen (Hwang et al., 2015). Here, an experiment is done using podcasts, where secondary time can be used for learning, for example while bicycling.
Danish cities in boast good infrastructure and a culture of bicycling as means of commuting. The time people ride bicycles is generally not used to conduct practical matters, and conventionally not to conduct university studies. It was the intent of this study to develop teaching material for students which could be studied while riding bicycles. This was achieved by recording podcasts where pre-requisite material was covered in a popular manner, allowing students to listen to the recordings through mobile phones while riding bicycles. By doing so, students can avoid investing primary time into learning, but could use time that was already spent on activities (Moura, 2008).

II METHODS

Recordings where made using Audacity, a free audio recording platform (Audacity, 2013). In order to obtain good sound quality, an M-One USB condenser microphone was used. The podcasts then follow the following overall script. First, a light jazz intro is played followed by an introduction to the topic. The second half of the podcast was then devoted to interview a researcher in the field which the particular podcast episode covers. Four key topics where be covered through podcast recordings. 1) Electronic waste with Keshav Parajuly 2) Circular Economy with Henrik Grüttner 3) Life Cycle Assessment with Hafþór Sigurjónsso and 4) Product development implementation where Tony Baho, a senior designer at Volvo was interviewed. Each episode was designed to be long enough to cover the essential core of the topic at hand but short enough to be listened to while commuting on a bicycle (Milakis et al., 2015). The duration of the shortest podcast was 10:18 and the longest 18:05. The recordings where then uploaded to http://www.reyniratlason.com, where the podcasts could only be accessed with a password. The password in this case was "sustainability". By uploading the podcasts to a personal website, and restricting access, it was possible to monitor traffic through this particular part of the website.
Through traffic monitoring on http://www.reyniratlason.com it can be seen that traffic increases from August throughout October. In fact, it can be seen that 30% went to the Podcast part of the website. This number should however be added to the part which visited the "Home" part of the website, as visitors are automatically navigated there before accessing the podcasts. As can be seen in Figure 1, one can estimate that roughly 65% of visitors went to the podcast part of the website. In September, 30 individual visits from separate computers or mobile devices were made to the website, resulting in approximately 19 visits by different individuals to the podcast section. Using the same method, one can estimate that 17 individuals visited the podcast section in October. The class consists of 40 students. This indicates that a little less than half of the class took the initiative to listen to the podcasts.

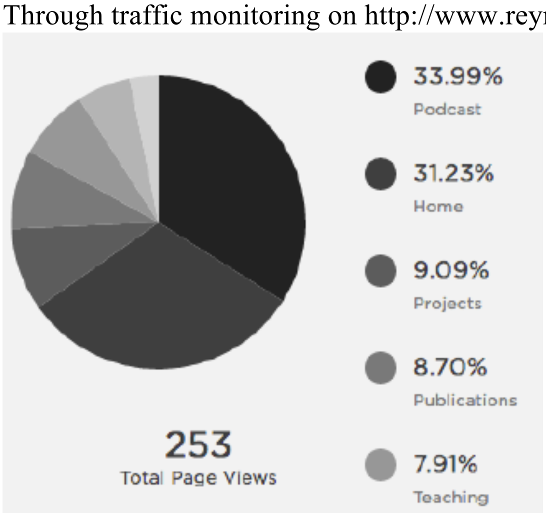

Figure 1. A pie chart indicating where visitors navigate within http://www.reyniratlason.com

In order to visualize if students found the content, or its delivery method to be of value, an online questionnaire was distributed and analyzed. Students were asked to evaluate their understanding of certain topics which had already been covered in class. Some of those topics had been introduced through the podcasts, while others had only been covered in class. Students were asked to rate their perceived understanding of the material on a scale from 1-4. A rating of one indicates no-understanding of the material while 4 indicates a large increase in perceived understanding. Students (n=17) were asked to indicate if they had listened to the podcast, and if so then which episodes. Finally, students were asked to indicate their engineering background. Results were statistically analyzed in order to visualize if the podcasts had an effect on students perceived understanding of the material at hand and if students found themselves understanding the material covered in the podcasts better than material only covered in class.

III RESULTS

Composing and recording a podcast is a more time consuming endeavor than initially assumed. It was found that each episode composed of approximately 5 hours of work. This included deciding the topic, creating a rough manuscript, locating a relevant person for an interview, conducting the interview and then finally editing the episode before uploading to the website. It was furthermore experienced that a certain level of stage fright became apparent from the author after uploading a podcast online. This was however shadowed by the positive response from the students, who indicated their liking of the material in class. More podcasts were even required by some students.

In Table 1, one can see averages on how students graded their perceived understanding of the topics covered by the podcasts. It should be noted that the sample of students participating in the survey was small, limiting the possible conclusions from this study. However, it can be seen that there seems to be no significance for students with environmental engineering background. This may be because of their previous education, and that they have very likely been exposed by the material previously. However, the PDI engineers, who were the target group, found themselves to understand the topics at hand better if they had in fact listened to the podcasts. The difference can be seen clearly when looking at the topic of E-waste, where those who did not listen to the podcast found themselves with a marginal increased understanding of the topic, scoring on average 2. Those who listened to the topic did however score on average 3.3, indicating a deeper understanding. In fact, PDI students found themselves understanding all topics better if they listened to the podcasts.

Table 1. Average rating of perceived understanding between students based on engineering background

	Did not listen (All)	Listened (All)	Did not listen (Env.)	Listened (Env.)	Did not listen (PDI)	Listened (PDI)
E Waste (Episode 1)	2.1	2.3	2.2	1.3	2.0	3.3
Circular Economy (Episode 2)	1.9	1.8	2.0	1.3	1.8	2.3
LCA (Episode 3)	2.3	2.0	1.8	1.0	2.7	3.0
Practical implementation (Episode 4)	2.9	3.5	2.6	3.3	3.2	3.7

VII CONCLUSIONS

In correlation with previous studies, podcasts were found to be a suitable method for delivering introductory material in a multi-disciplinary class (Kratochwill et al., 2016; Liao et al., 2013). It was found that approximately 50% of students used the opportunity and engaged with the material. This research however suffers from a small sample size of students evaluating the learning outcome from the podcasts, limiting the conclusions to be made from this study.

Students with a PDI engineering background, were found to gain a deeper understanding of the topic at hand if they had listened to the podcasts. It can therefore be assumed that podcasts are potentially a valuable tool to provide relevant background material some students may be lacking. Locating which material that may however be is another matter and a subject for a future study.

After the test semester had finished, several students reached out with ideas on the future developments of the podcast. The suggestions included topics, music themes and relevant people to interview.

It was found that podcasts allowed students to use secondary time to gain basic understanding of certain topics. There are therefore no hurdles in using the same method for other classes taught by the author. Another class, “Consumer product testing and optimisation”, partially taught by the author is also consisting of engineers from various backgrounds. The class may therefore be well suited for podcasts, where students gain deeper knowledge about certain aspects taught in class.

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BIOGRAPHICAL INFORMATION

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Abstracts/Papers
Hands-on Session 2
Tuesday 13.00 - 14.30

	Hands-on 1 Room 3.0.02	Hands-on 2 Room 3.1.15	Hands-on 3 Room 3.1.16	Hands-on 4 Room 2.0.08
	The Shanzu case - an open online problem based learning platform	Micro-Skills Triads for Training STEM Teaching Assistants to Support Active Learning	Educating reflective practitioners in large classrooms	Teaching in the International Classroom
Author(s)	Jette Egelund Holgaard Mona-Lisa Dahms	Siara Isaac Cécile Hardebolle Roland Tormey	Joana Geraldi Christian Thuesen	Tina E. Bahrenscheer Jens Myrup Petersen Helle N. Olsen
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The Shanzu Case – an open online problem based learning platform

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ABSTRACT
Keywords – problem based learning, online learning, knowledge sharing worldwide, engineering education

Type of contribution: _X_ hands-on.

BACKGROUND
In a problem based learning environment engineering students are expected to work with authentic real life problems embedded in a given context. The ideal approach would be to bring students out of the university and into the given context to gather data. This approach may be too costly, especially if the context if far away from the university. The second best option is to bring the problem in the form of a case scenario, including a realistic presentation of the given context, into the university or - as in this example – bring it onto an open online learning platform that can be accessed by students anywhere in the world.

EXPLANATION
The present case scenario (Andersen and Schiano, 2014) takes its point of departure in a water and electricity project in the Shanzu Transitional Workshop for Disabled Women. The workshop is located in Shanzu in Kenya and the project was funded by the Poul Due Jensen Foundation. The project developed over several phases and the learning material is structured in four modules according to these phases. Students cannot enter a new phase before they have completed assignments from the previous phase. This modularised approach forces students to move through the project phases, having to make decisions on the same issues that the project engineer faced during the project. Thus, as students work through the material they have an opportunity to develop from what Dreyfus and Dreyfus (1980) call the novice stage to a stage of competence, with the project engineer by their side.

SET-UP
The learning material consists of two knowledge platforms: An academic knowledge platform, including learning objectives, online theoretical lectures and student assignments and a contextual knowledge platform containing videos, interviews, problem presentations, presentation of dilemmas, instructions and chosen solutions by the project engineer etc. Through this mix of educational material the students engage with the three aspects of learning: Knowing, acting and being, the latter involving personal reflections and normative decisions (Barnet and Coate, 2005).

EXPECTED OUTCOMES
For students using the online learning material the expected outcomes are:
- Provide opportunities to work with a problem based learning case
- To gain a sense of real life engineering in an unfamiliar cultural context.

For participants in the hands-on session the expected outcomes are:
- Knowledge about the learning material as a potential resource for your own teaching
- Inspiration to create problem based online learning material.

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Micro-Skills Triads for Training STEM Teaching Assistants to Support Active Learning

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ABSTRACT

Keywords **-** Graduate assistants; evidence-informed teacher training; subject epistemology

Doctoral teaching assistants are frequently present when students are most active, such as in labs and exercise sessions (Fagen & Wells 2004), yet typically get little pedagogical training (Cox et al. 2011) and what training is offered may be generic rather than specifically adapted to the subject epistemologies of science and engineering (Luft et al. 2004, 213). Yet if teaching assistants are to effectively support students in active learning environments, their tendency to see undergraduate students principally as "receptacles of information" (Gardner & Jones, 2011) is problematic as it reveals the belief of many that their role is to provide "good" information rather than to assist students figuring things out themselves (Luft et al. 2004).

This **hands-on session** will allow participants to experience a 60 minute triadic role play activity which addresses specific teaching methods associated with STEM disciplines. The design is informed by key findings of our review of evidence on teacher training in science and engineering, namely the challenge of *enactment in practice* or *transfer of learning* from the training workshop into the classroom (Darling-Hammond, 2006). The three STEM specific micro-skills practiced in the role play are:

a. Teaching by questioning (rather than by explaining).
b. Providing feedback that aids student self-regulation.
c. Teaching a scientific/mathematical problem-solving method.

The 175 doctoral teaching assistants who provided feedback through evaluation questionnaires in the 14 sessions organized since 2014 have expressed broad agreement that the micro-skills triads were useful for developing these skills. Further, 75% of participants strongly agreed that they were quite likely to try the skills in practice. This shows that participants not only saw the skills as useful but that they also felt that they had been taught in a way that facilitated their transfer into practice.

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Educating reflective practitioners in large classrooms

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Keywords – project management, large classrooms, reflective practitioner, reflexivity, sustainable developmental goals.
Type of contribution: hands-on practices

ABSTRACT

Projects abound in society, and turned from an 'accidental profession' to an attractive career path (Pinto & Kharbanda, 1995). In this line, engineers and engineering students are increasingly recognizing the criticality of project management to their own profession. The consequence is that we need to educate an increasing number of students in project management. At the Technical University of Denmark (DTU) - one of the leading engineering universities in Scandinavia - the number of students taking our courses has increased organically from 150 to over 300 in the last 5 years - a number that is believed to grow even further in the coming years. We thus face the challenge of educating an increasing number of students.

One alternative is a focus on traditional learning methods, multiple-choice exams, and a deterministic learning path. However, such tactic is unlikely to develop the reflective practitioner that are required in practice, as seminally argued by Schön (Schön, 1983, 1987), and also applied and argued to project management specifically (Crawford, Morris, Thomas, & Winter, 2006). This hands-on section will describe and analyze our experience – successes and failures – our program to change education of project engineers at DTU with the vision to educate large number of students and enable them to reflect and experience how to DO projects, as oppose to teaching normative tools and techniques.

This hands-on section will facilitate discussion about practices to encourage the development of reflective practitioners in large classrooms. It will do so by creating a context for you to experience being a student in a large classroom, and hence being detached from the 'actual author of the work'. Akin blended learning strategies, you will watch an introductory video, and you will do individual and group exercises, discussing your experiences and this experience of being detached from the 'teachers'. The discussion will be facilitated by another person (instead of the authors), which will act like a 'teaching assistant', as students experience in large classrooms. We will instruct this other person, but will not be there in the discussions itself.

We then join by the end of the discussion, when we will close the session sharing our practices and experiences in dealing with large classrooms. Our program included thirteen mini-projects with implementation of peer grade, blended learning, modularization of education, ISO21500 certification, project games, development of flexible teaching material, embeddedness of project

management throughout student practices, connection to societal and global challenges, industry advisory board, and the development of a Project Laboratory.

Our work makes two key contributions. First, it points to some pragmatic struggles directly from the classroom, when attempting to reach out to large number of students, while not compromising on a practice approach to projects, and still carrying out an active research career. Second, it positions the relevance of a holistic and systemic view on university education of project managers to engineers.

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Teaching in the International Classroom

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ABSTRACT

Keywords - *The international classroom, internationalisation criteria*

Please indicate clearly the type of contribution you are submitting: _X_ hands-on, ___explore, ____poster.

I. BACKGROUND

There is a growing awareness that intercultural competence required for global contexts are equally important for living and working in today´s increasingly diverse and multicultural societies. This has an impact on how universities face growing complexity in their classrooms. Internationalisation can facilitate an inclusive intercultural dimension to the teaching that is important in if we want future engineering students to be prepared for a more and more global- and mobile marked.

II. SET-UP

The workshop on Internationalisation will focus on translating the participants' ideas and experiences into hands-on recommendations on internationalisation in engineering education, with a focus on how we work with international students and in international student environments. The workshop will be relevant for all teachers working with international students in Denmark or abroad, and focus on three aspect, all with the international learner in mind: Designing project work, giving lectures, and planning the introduction of international students to our educations.

The session is organised with a short introduction followed by group work in three tracks according to the aspects mentioned above. At the end, the groups present their most important contributions.

III. EXPECTED OUTCOMES/RESULTS

The workshop will result in a set of recommendations for internationalisation in engineering. The recommendations should be hands-on and useful for all teachers dealing with international students or international student environments.

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Abstracts/Papers
Explore Session 2
Tuesday 13.00 - 14.30

	Explore "Yellow Room"
	1:Industry university cooperation regarding integrated water treatment and recycling in a graduate course 2: Expert in Teams Course Demands Work on Real Problems 3: Experts in Teams – A learning method 4: On the impossibility of generally bringing core subject competencies into play in innovation teaching
Author(s)	1: Birgitte L. Sørensen and Henrik Grüttner 2: Erik S. Madsen 3+4: Steffen K. Johansen
Chair	Regner B. Hessellund

Industry university cooperation regarding integrated water treatment and recycling in a graduate course

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ABSTRACT

Keywords – Industry cooperation, water treatment, environmental engineering, sustainability

Identification and application of technologies for sustainable, integrated water treatment in the industry requires a holistic approach – a system approach. This includes understanding the environmental situation of the actual industry, the process and the characteristics of and specifications for the quality of the water. This of course must be combined with an understanding of the characteristics and economy of the different treatment options.

Looking at this challenge as a system analysis has proven to be a useful approach to solving such equations. Much information is already available in the industries if you know how to ask and combine the data.

This approach is applied in a 10 ETCS master course called 'Industrial Water Technology' at the Faculty of Engineering at the University of Southern Denmark from 2010 and onwards.

Except for an initial assessment performed along with the initial contact and agreement, the case industries are not studied in details beforehand – the students under the supervision of the course teachers do all data acquisition. This means that the students feel the challenge and responsibility to provide a reliable result, which is typically highly motivation for them. Further, we explain to the students how the project is remarkably similar to a real life job as environmental technology engineer working as a consultant to the industry.

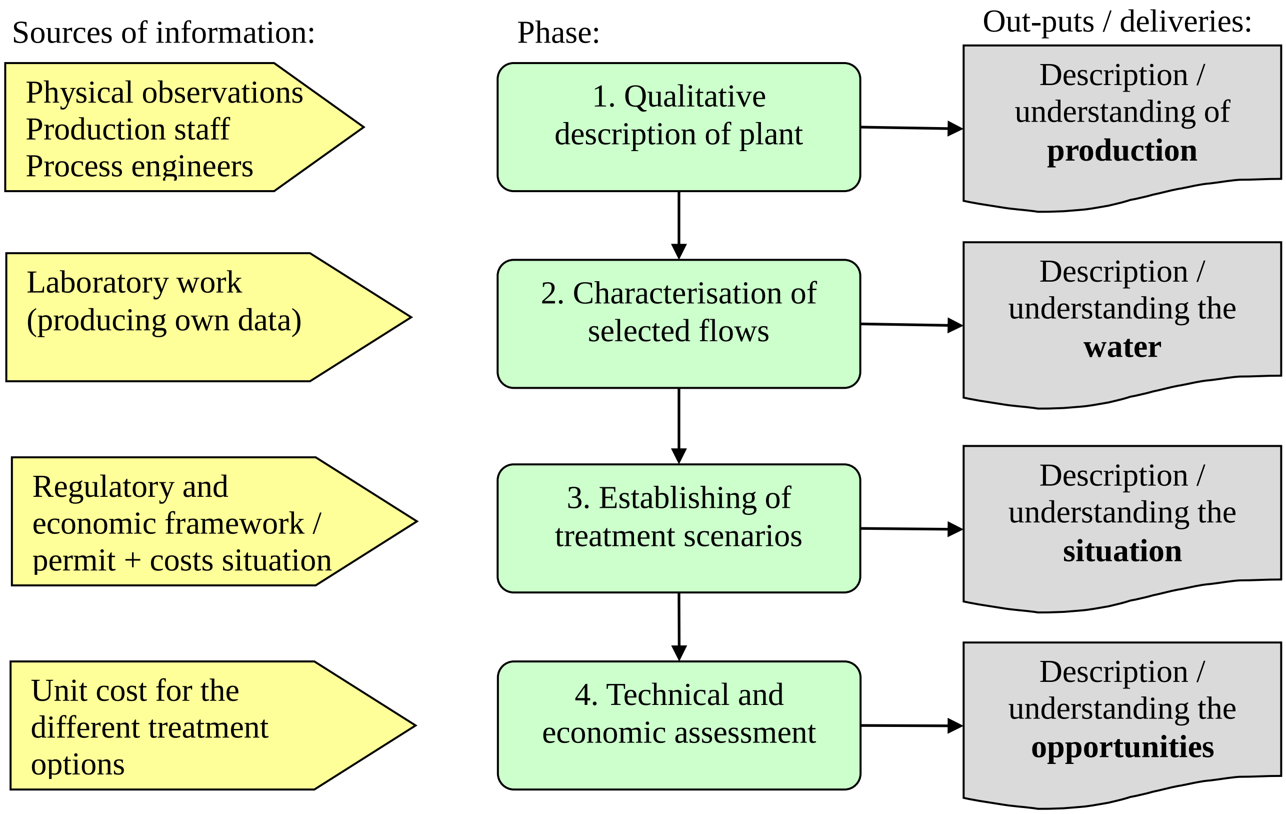
Course design

Overall the course falls into four parts:

1. Mapping the production process – collecting available information
2. Characterisation of the water flows and lab-testing of the treatment options
3. Modelling / creating scenarios
4. Technical and economic assessment

The first challenge is to generate an understanding of the production mainly using existing/available information. This means visiting the case industry studying the production process, interviewing the relevant persons and collecting data regarding the present situation. All groups on the course visit all industries but only one group continue working with the actual industry. The group must present their finding to all the groups, and in this way, we check if they have missed crucial bits of information.

This presentation includes their first attempt to create a production flowsheet with water and mass balance. Joint with an assessment of the nature of the raw materials and auxiliary substances applied, and how it is framed by the legislation on the wastewater discharge and available data regarding the wastewater plus a clear definition of the challenge the industry is facing – equal to the task of the team.



The second phase of the course provides a combination of presentation of theory regarding relevant treatment techniques and testing of the options in the laboratory on water from the case industries.
The treatment options covered are simple filtration, settling, chemical precipitation, membrane filtrations, biological treatment (aerobic and anaerobic) and chemical oxidation. The testing performed is in true lab-scale systems and combined with simple characterisation methods like COD, total and suspended solids, loss of ignition, etc. The purpose is to make the students have a 'feeling' of the actual water with the minimum amount of laboratory work since the aim of the course is not to train laboratory work skills. In a few cases, the case industry pays to have more specialised analyses performed by external laboratories.

Along with the theory/laboratory part the students we encourage to start considering what treatment options they see for their case. Part of this challenge is to try to identify the quality aspects for the water recycled back to the production and considerations on where in the process to apply the water. Both aspects naturally challenge their understanding of the production process and often create a need for new consultations to the case industry or other sources of information regarding the actual industry – like, for example, suppliers of equipment or chemicals. Further, we initiate the assessment of the possible disposal routes for the generated concentrates.

Finally, the students use all the collected and generated information to establish a number of treatment and recycling scenarios, which are technically and economically assessed. During this process, the students often see a need to refresh their understanding of the different treatment options and check part of information regarding the production. The main challenge in this phase is to identify the economic parameters for equipment, installation and running costs in order to calculate the payback period for the different scenarios. This often creates a need to consult the potential suppliers of treatment plant equipment providing additional understanding of the options.

Experience / outcome

Till now the following industries has been involved; a brewery, a paper mill, a textile finishing plant (a 'dye-house'), a carpet manufacturing plant weaving and dyeing synthetic carpets, a hospital laundry and an industrial mat laundry.

The value of the outcomes for the industries depends on the industries actual status and need for the results of the projects. Mostly some ideas for possible initiatives are unravelled and made available to develop further. Probably the most significant outcome for the industries is the overall assessment that sometimes reveals obvious new ideas they are not aware of.

The design of a course with open cases/problems provides a high degree of focus on the students and creates a high degree of motivation. This is experienced in a high degree of ownership to the cases. In this way, the motivation to work with generic aspects required to perform the holistic assessment is strongly encouraged /Søtoft and Grüttner, 2012/.

The feedback from the students in the form of the standardised course evaluation has been extraordinarily positive and so has the verbal feedback received during the course. A large part of the students are non-Danish, and the course structure makes them learn much on the Danish /EU legislative background of water treatment and Danish industrial practices.

Obviously the course design provides use of all steps in the taxonomy of Bloom /Bloom, 1956/; Acquire knowledge (step 1), understand (step 2), use (step 3), analyse (step 4), generate new solutions (step 5) and assess the developed solutions (step 6) which requires understandings of more complex interactions. Further, it is consistent with the The Engineering Education Model of SDU (EEM/DSMI).

Typically, they experience a period of frustration when they realise the expectations towards them. Later this turn into satisfaction once they realise they are able to perform a proper analysis the industry values. At the individual, oral examination with an external examiner, the students show:

- To be highly skilled in assessing the developed solutions,
- A good understanding of the problem the group has worked with, and
- The ability to identify possible limitations to their conclusions and perspectives on further work needed.

To conclude, the use of real life cases - where the solution is unknown beforehand - gives the students motivation and ownership to the cases and makes them provide excellent results.

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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.

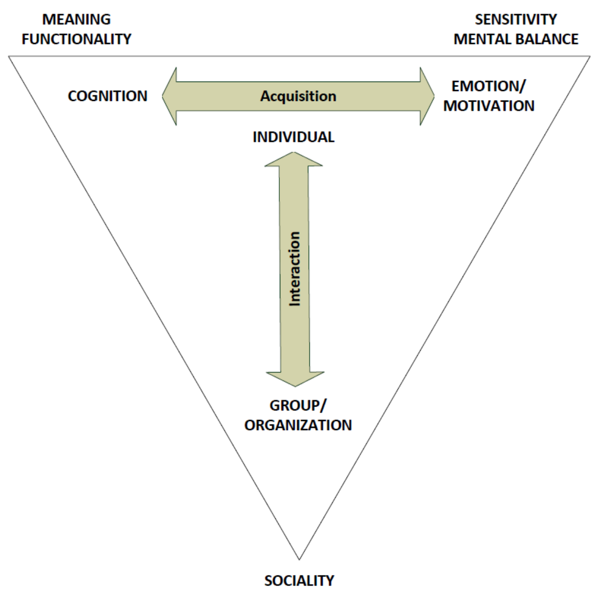

Figure 1. Dimensions of learning (Inspired by Illeris, 2003)

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

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

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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Experts in Teams – An experiential learning method

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ABSTRACT

This study discusses the pedagogical characteristics of the hands-on interdisciplinary innovation course Experts in Teams (EiT) of the University of Southern Denmark (SDU).

EiT is a 10 ECTS course mandatory to all fifth semester students on any engineering program at the Technical Faculty of SDU. Course duration is 12 weeks with two weekly sessions of which only one is teacher controlled. In 2016 EiT involved approximately 425 students, 22 teaching resources, and 6 companies. These numbers will increase in the years to come.

Traditionally we distinguish between practical courses and theoretical courses. Most of the practical courses are group work along the lines of project based learning. EiT is in a way both. It is a practical course in as much as our students get hands-on experience with interdisciplinary team work and innovation processes. EiT is a theoretical course in as much as our students are taught various tools that aid and guide them in the innovation process and in the interdisciplinary team work.

The theoretical foundations of EiT viewed as a teaching method is experiential learning and its derivative project based learning. In the beginning of the 12 weeks course period EiT is taught much like a traditional theoretical course. After only a few weeks this all changes and the teachers become facilitators of the students' own learning which is relevance-steered by the innovation project at hand. These characteristics are typical for experiential learning and in this way EiT becomes a learning method rather than a teaching method.

Besides discussing the pedagogical characteristics of EiT, the study also gives a general introduction to EiT as it was taught at SDU fall 2016 as well as a brief review of the basic theory behind experiential learning. As such this study serves both as an introduction to e.g. new teachers of EiT but also as a starting point for a clarification of the features that makes EiT an experiential learning endeavor.

Keywords **-** hands-on innovation teaching, interdisciplinarity, teaching method, learning method, experiential learning, project-based learning, Kolb's learning theory

I INTRODUCTION AND MOTIVATION

In 2001 a new course named "Eksperter i team" or in English "Experts in Teams" (EiT) was launched at NTNU in Bergen (Sortland, 2015) (NTNU, 2016). Since then several other universities in Scandinavia have installed similar courses – all inspired by the NTNU course.

At the Technical Faculty (TEK) of the University of Southern Denmark (SDU) EiT was launched in 2006. EiT is mandatory for all students of TEK, i.e. all SDU engineering students and is placed on their fifth semester. For students from other faculties the course is an elective. Our students work in interdisciplinary and preferably cross-cultural[1] teams on an innovation process (or at least parts of it). The course is very hands-on and learning-by-doing and it is so in a student-directed way with little lecturing and only a small

[1] Here I take 'cross-cultural' to mean 'international' (more or less).

amount of prescribed literature. Essentially EiT at TEK/SDU is very similar to EiT at NTNU though at TEK/SDU we emphasize a bit more the innovation part of the course at the expense of the facilitation part (more on this later on).

At TEK/SDU EiT is a consequence of the "The Engineering Education Model of the University of Southern Denmark" (DSMI) - an education model that goes for all engineering programs at TEK/SDU[2]. Among the drivers for DSMI is a perceived demand from society to turn to good account the many hours our students spend at obtaining their diplomas by endowing our students with employability skills and competences of a more general character.

Obviously EiT at TEK/SDU is not a conventional university course. The features described above set it apart from the traditional teacher directed university courses with a well-defined course curriculum and course syllabus. The question as to what kind of teaching method EiT is naturally arises. The answer, I suggest, is that EiT is an experiential learning method.

In the following I will try to describe in more detail the characteristics of EiT as a teaching and learning activity. At the same time I will highlight important elements of the organization of EiT at TEK/SDU. Knowledge of experiential learning theory is required in order to appreciate the experiential dimension of EiT. Therefore I will start out by giving a very brief introduction or brush up to this topic. After the introduction of the theoretical framework I turn to the practical aspects of EiT as it is implemented at TEK/SDU. Finally I discuss the characteristics of EiT that identifies it as an experiential learning course.

II EXPERIENTIAL LEARNING

Introduction

It comes as no surprise that EiT fits the characteristics of a project-based learning (PBL) method well – after all PBL is mentioned in DSMI. Somewhat less trivial is the notion of EiT relying on experiential learning to achieve the learning outcomes. What exactly does this entail? What are the foundations of experiential learning? And what is e.g. the difference between experiential learning and PBL?

Kolb's experiential learning theory

Back in the 1970s Kolb and Fry developed the basics of what is now known as the experiential learning model (Kolb & Fry, 1975) (Kolb, 1984). The model is typically illustrated as shown in Figure 1 (Chapman, 2013) where the black boxes represent stages in the learning cycle, the red boxes are associated learning styles, the blue box with arrows represent a processing continuum (doing or watching), and finally the green box with arrows represent a perception continuum (feeling or thinking).

Learning is seen as a continuous process where individuals are actively involved in new experiences, reflect on what has taken place, theorize about the experience, and finally apply this knowledge to new situations (Kolb, 1984). Kolb focuses on the process of learning and not on the concrete learning outcomes and talks about knowledge as created through the transformation of experience.

[2] In the following I will consider only the TEK study programs of campus Odense. TEK/SDU has a campus also in Sønderborg where the students of course also have EiT. EiT Sønderborg is, however, a course separate and different from EiT Odense.

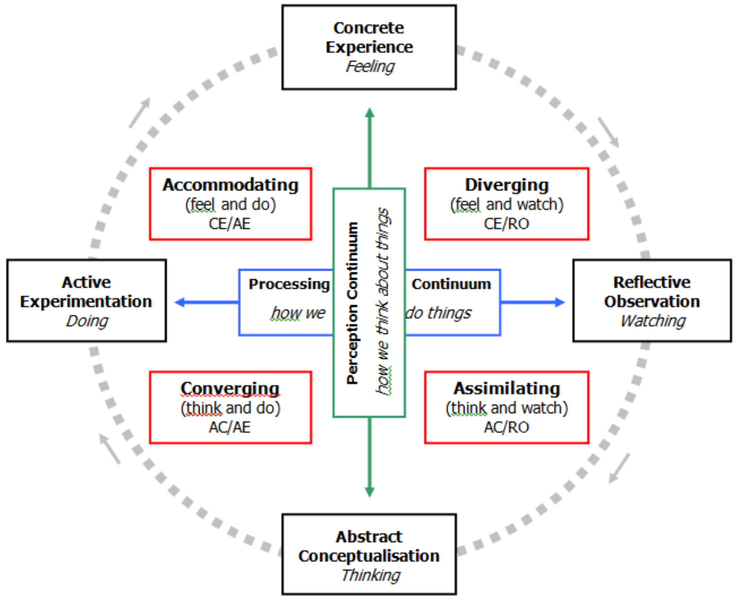

Figure 1: Illustration of Kolb's learning model (Chapman, 2013)

It is beyond the scope of this study to give a full interpretation of Kolb's theory. Here I shall emphasize the two relatively trivial facts that: 1) experiential learning begins and ends with the students active involvement in an "experience" and 2) that deliberate and explicit reflection on the actual outcome of the experience as opposed to the believed outcome prior to the experience is of paramount importance to consolidate new knowledge (Association for Experiential Education, 2007-2017) (Kolb, 1984) (NTNU, 2016).

Project-based learning

Experiential learning takes many forms (Garlick, 2014). Of particular interest to this study I shall mention *problem*-based learning and *project*-based learning where the latter can be seen as a further development of the former. In the literature both are referred to as PBL-methods.

Problem-based learning is an approach that involves real-life problems and their solution. The focus is not on how to apply certain methods to a given problem – that would be the traditional way to go about it. In problem-based learning the focus is on determining e.g. what methods are appropriate to solve a particular problem – which may well involve self-learning of those methods. Supposedly it therefore develops the skills of reflection, reasoning, and observation as opposed to just being presented to and collecting facts (Garlick, 2014). The problem itself could also be developed or refined by the student.

When the problem takes on a project-like character and starts to consume a substantial amount of time then the problem-based learning becomes project-based-learning. Clearly the scope of a "project" is wider than the scope of a "problem". The "project" may involve several problems and require multiple methods and lots of project-specific knowledge.

PBL, be it problem or project based, are not intrinsic group-work methods, and it is entirely possible to do PBL as an individual activity.

Learning outcomes and experiential learning

The curriculum is replaced by reflection on the "experience" the student have had during the course (NTNU, 2016, p. 16). Reflections on an "experience" leave ample room for the actual learning outcomes to be very different from student to student and they become subjective in the sense that they depend on the individual experiences of the students. In general this means that the learning outcomes of the course description of an experiential learning based course will be much less tangible – border lining vague - than the learning outcomes of a traditional curriculum based course.

Teacher versus facilitator

With subjective student dependent learning outcomes clearly also the teacher role of experiential learning must be very different from the teacher role of a curriculum based course. The teacher's role will no longer be that of presenting e.g. theories to the students. Instead the teacher role becomes that of a facilitator. During experiential learning, the facilitator's role is to (Association for Experiential Education, 2007-2017):

- Select suitable "experiences"
- Pose problems, set boundaries, support learners, provide suitable resource, ensure physical and emotional safety, and facilitate the learning process.
- Recognize and encourage spontaneous opportunities for learning, engagement with challenging situations, experimentation (that does not jeopardize the wellbeing of others) and discovery of solutions.
- Help the learner notice the connections between one context and another, between theory and the experience and encouraging this examination repeatedly.

Critique of experiential learning

It should be noted that not everybody agrees that experiential learning is all it claims to be. Apparently research shows that only when a sufficient level of prior knowledge is reached does experiential learning provide a better alternative than the traditional curriculum base courses with guided instruction are almost always superior (Kirschner, et al., 2006).

Besides the more theoretical considerations of the problems with experiential learning, students and professors alike also complain that PBL in general leads to redundant research and non-constructive speculation (Provan, 2011).

III EXPERTS IN TEAMS: THE COURSE AND ITS ORGANISATION AT TEK/SDU

Introduction

The following section describes in some detail the organization of the course EiT at TEK/SDU. The course I deeply rooted in "The Engineering Education Model of the University of Southern Denmark" (DSMI) - an education model that all engineering programs at TEK/SDU adhere to (SDU/TEK, 2015). DSMI is discussed first and then the actual organization of EiT fall 2016 is discussed.

DSMI

The purpose of DSMI is to establish a foundation for the engineering programs at TEK/SDU. It is both a model and a strategy for how to construct an engineering education program. As a strategy it seeks to ascertain that the skills and competencies of the SDU engineers comply with market demand. As a model it outlines the organization and constituent components of an SDU engineering program.

Albeit recognizing the importance of traditional theoretical lecturing courses, the model puts emphasis on active and project based learning. On each of the first 4 semesters of any engineering program at SDU, 10ECTS are reserved for a semester project. In the semester project the students do project based group work on real-life problems. The semester projects let the students work with the theoretical content of the semester in an applied way. On the 5th semester EiT takes the place of the semester project. The students are put in interdisciplinary groups and asked to work with real-life innovation. There is no overlap, except by coincidence, between the EiT project content and the rest of the courses the students are taught on that semester.

The project based learning approach reflected in DSMI is considered not only to facilitate deeper learning of the semesters' theoretical content but also to strengthen general skills and competences. The following general skills and competences are mentioned in DSMI (SDU/TEK, 2015).

Engineers trained at SDU must have the capacity to:

- Work independently and be able to:
  - Plan strategies for their own learning process
  - Evaluate their own learning process
  - Focus in-depth on technical disciplines
  - Formulate and analyse a problem in a structured manner
- Cooperate and be able to:
  - Work in an interdisciplinary context
  - Work with people from other academic and cultural backgrounds
  - Document and communicate their knowledge and results verbally and in writing to different target groups
  - Evaluate the work of others and give them feedback
  - Work in a project-oriented context and in teams
- Apply their knowledge, skills and competencies in practice and be:
  - Receptive towards new problems and solutions
  - Innovative and creative
  - Solution-oriented

These general skills and competencies are all clearly targeted by the semester projects and EiT in conjunction with EiT covering the interdisciplinary and innovative competencies.

A progression in openness of the semester projects is intended with DSMI. At the first semester the problem of the semester project will thus be fairly closed while it will open up more and more during the following semesters. Clearly this also leads to a progression in student-directedness and on the fourth semester the students may even be responsible for formulating the problem of their semester project and seeking the necessary information to solve it themselves, i.e. on the last semesters the students' work with the semester project comes very close to experiential learning.

The semester projects and EiT are the ECTS points that most obviously target the general skills and competences of DSMI mentioned above. Of course students also work their core subject skills and competencies in the semester projects but in EiT this changes somewhat.

Organization of EiT

EiT at TEK/SDU is a 10ECTS mandatory course for all engineering students at the fifth semester. Exchange students usually visit at their fifth semester and most of them take EiT corresponding to 5-10% of the total number of students on the course. Occasionally also a couple of students from other faculties might choose EiT but they do not constitute any significant group.

The course thus far only runs in the fall – mainly because all engineering programs start after summer. All fifth semester time tables have Wednesdays' and Thursdays' afternoons reserved for EiT from 12.15-15.45. Wednesdays are teacher controlled whereas the students are on their own on Thursdays. The time slot on Thursdays is reserved in the timetables to make certain that students from different programs have opportunity to meet and work together.

The students of EiT at TEK/SDU, counting hundreds, are divided into themes of around but preferably not above 40 students per theme. The themes are introduced to the students on the first day of the course and each student is invited to prioritize 3 themes. The students' preferences determine in which theme they are placed. Of course promotion of interdisciplinarity and cross-cultural group work must also be taken into account. Therefore an ad-hoc maximum on the number of students from the same engineering program in a theme is used. Likewise exchange students are divided equally among the themes. Not all students will therefore be given their first priority theme - but in the order of half the students half will. The rest will be given their second and third priority theme with only a few being given the latter.

In the themes the students are again divided into teams of 5-6 students. Also here interdisciplinarity is ensured by allowing only two students from the same program in each group. Likewise exchange students are distributed evenly among the groups. The groups must be formed in week 2 of the course. There is no central policy on how to form the groups and the teachers can use whatever method they see fit. In some themes it is left for the students to decide for themselves, in some themes the teachers simply decide, and in some themes some other method is preferred. Some students always complain that the group formation process could have been better.

Two teachers are allocated to each theme. They are ultimately responsible for the theme curriculum although the curriculum is being developed in strong collaboration with the EiT coordinator.

Examination

The students hand in a series of deliverables at the end of the course. Together with an individual oral defence and a group presentation those deliverables are evaluated and an individual grade is passed. The deliverables count an individual learning report and 3 group hand-ins: a concept and skills poster, a collaboration poster, and a business report.

Learning outcomes

To walk through the individual learning outcomes of EiT is beyond the scope of this study. It suffices to say that they all target the general skills and competences of DSMI mentioned above which also makes them somewhat intangible and vague. The course description mentions innovation process and interdisciplinary team work to be at the main "experiences" of the course - all very much along the lines of experiential learning as I shall discuss later on.

The EiT themes

Two factors shape our themes:

1. the overall course objective that our students should encounter real work-life innovation processes and
2. the requirement that in the ideation phase of the course all students should be able to bring their core study-program competencies into play.

Since the vast majority of our students are students of engineering the above mentioned factors reduce to (at least) requiring of the themes that they should be engineering relevant, i.e. they should deal with the types of problems that engineers would normally encounter "out there".

We use the two concept pairs *entre*preneurial/*intra*preneurial and push/pull to classify our themes. In *entre*preneurial themes the students work with start-ups, i.e. they qualify their value propositions assuming that they are a start-up company. In *intra*preneurial themes the students work with innovation within an existing company, i.e. they qualify their value propositions on behalf of the company.

Typically a theme will work with a company in an intrapreneurial setting. The company presents a problem framework within which the students then innovate as if they were a project group in the company.

We also have pure entrepreneurial themes. These themes could reflect one of TEK/SDU's core research areas, e.g. drones. The groups in such a theme work in a push-like entrepreneurial manner with the aim of qualifying an idea and pitch it to investors. Some entrepreneurial themes are not as such thematized. Here the students have freedom to develop and qualify any engineering relevant idea they might come up with, again with the ultimate goal of pitching it to a potential investor.

IV EXPERTS IN TEAMS: AN EXPERIENTIAL LEARNING METHOD

With the theoretical framework on experiential learning and the description of EiT at TEK/SDU fall 2016 in place we are now ready to identify and highlight the characteristics of EiT – or at least some of them - that makes it an inherent experiential-learning based course.

Characteristic 1: The ideation phase – phase 1 of the innovation process

As stated above our students are presented with very open problem frameworks and asked to develop and qualify an idea within that framework. They are given tools for ideation but after that they are left on their own to do the actual ideation. They are responsible for providing the information they need on e.g. markets and technology. Nobody but themselves drives the process.

Characteristic 2: The qualification phase– phase 2 of the innovation process

In this phase the students are also on their own in as much as they are the ones who have to identify in what ways it is relevant to qualify their idea. They are given tools - examples could be budgeting tools or Osterwalder's business model - which they can use in the qualification phase, but it is up to themselves to select and obtain all the data they need for the qualification.

The characteristics of both the ideation phase and the qualification phase distinguish both as Kolbian learning experiences rather than as part of a traditional course curriculum.

Characteristic 3: Reflection on the interdisciplinary team work

Throughout the course the students are asked to reflect on the interdisciplinary team work. Again they are given tools which can aid them in this but essentially the interdisciplinary-team-work-experience becomes a second Kolbian learning experience.

Characteristic 4: Reflection on own learning

As part of the examination the students are asked to prepare an individual learning report. In this report they reflect on their own learning. Both general engineering competences and specific core subject competences should be part of the reflection.

Characteristic 5: The role of the teacher

The teacher instructs the students in the use of various tools, e.g. collaboration- and ideation tools. The structured guidance in the use of such tools is very close to what would be expected in a normal curriculum based course, but the tools themselves are not part of the course curriculum – they serve only as suggested aids in the innovation – or group process. The teacher organizes the actual theme and coordinates with external partners but the teacher has little or no knowledge about the actual project framework and cannot serve as an expert on this. The main role of a teacher on EiT at TEK/SDU is that of a facilitator complying more or less with the facilitator characteristics mentioned above in section 2.

Characteristic 6: The learning outcomes

Albeit the course description is not explicit about EiT being experiential learning the learning outcomes are all very much what one would expect from such a course, i.e. somewhat intangible and vague and mentioning learning content only at a very general level with few if any particulars. In the course description we can identify the two processes of innovation and interdisciplinary collaboration as two "experiences" (cf. characteristics 1 and 2) the students have to analyse and reflect upon. In the end it is their ability to do exactly that, i.e. to analyse and reflect upon those two processes, which is evaluated at the examination.

IV CONCLUSIONS

The course Experts in Teams is characterized by being highly experiential in its organization. The students are presented with a problem framework within which they have to create a value proposition and qualify that proposition. This innovation process constitutes the learning experience in Kolb's terminology. Besides the innovation-experience the students also have to learn the importance and difficulty of interdisciplinary team work. This interdisciplinary-team-work-experience becomes a second Kolbian learning experience.

The students typically work in teams of 6. The team is on its own when it comes to identifying and obtaining the knowledge pertaining to innovation content itself. The teacher cannot in general be expected to be an expert within the project framework. The role of the teacher here becomes that of a facilitator.

The students are given tools to aid them in both learning experiences. These tools are presented to them as if they were part of a traditional course curriculum. However, the students are not as such evaluated in their theoretical understanding of these tools. If anything it is the reflection on the usefulness of the tools during their particular experience which is evaluated. Thus the course does not lose its status as experiential over this.

Besides the Kolbian learning experiences mentioned above other characteristics that define EiT as an experiential learning based course were identified and highlighted. The teachers clearly take on the role of a facilitator when they are working with the students on the innovation-process or guiding them on the reflections on the interdisciplinary team work. Finally it was also mentioned how the learning outcomes described in the course description closely fit the expected profile.

With this study I hope to have shed some light on EiT as it is taught at TEK/SDU in Odense. Clearly a course like EiT must always strive not only to adapt to the needs of the business world but also to incorporate the newest knowledge on innovation and interdisciplinary team work. This makes the course highly dynamic and not two semesters will be alike. Ultimately, however, the Kolbian learning experiences of EiT, i.e. the innovation-experience and the interdisciplinary-team-work-experience, will remain the two pillars on which the course is built – otherwise there would be no Experts in Teams.

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On the impossibility of generally bringing core subject competences into play in innovation teaching

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Keywords **-** hands-on innovation teaching, core subject competencies, interdisciplinarity, experts in teams

ABSTRACT

In interdisciplinary hands-on innovation courses involving large numbers of students, the difficulty of ensuring, that every student's core subject competencies come into play, quickly becomes a matter of concern. Many students object that time and ECTS spend on courses not adding directly to their core subject competencies might be better spend on courses that actually do. University policies, on the other hand, at times require the students to participate in such courses, i.e. by making the courses mandatory. A clash between students' expectations and reality may result.

In this study I argue, that it is in general impossible to bridge the gap between university policies and the students' expectations of always adding to their core subject competencies when it comes to mandatory interdisciplinary hands-on innovation courses subject to the fairly trivial constraint that ideation is part of the considered innovation process. In general it is simply not possible to construct such a course.

Most innovation processes entail, almost per definition, an ideation phase (Drucker, 2002). The ideation phase is where the project group comes up with possible solutions to the "opportunities at hand". The "opportunities at hand" are found within some project setting and often identified by the group itself. Unless one constrains the outcome space, there is literally no way of predicting what ideas will surface during ideation. Typically the project group selects one idea – or one "value proposition" in Osterwalder's terminology (Osterwalder & Pigneur, 2010) - to further improve, refine, and qualify during the next phases of the innovation process. Clearly the choice of value proposition should, among other things, be based on the competencies represented in the group, i.e. most of the competencies perceived to be necessary for working with the idea in the next phases should be present in the project group. This is, however, far from saying that every group member's core subject competencies can come into play. This is prevented by the element of chance or unpredictability that the ideation phase introduces.

Of course one can then try to play with the project settings and alter those in order to force the outcome of the ideation phase into something where all group members' core subject competencies do come into play. This will, however, almost inevitably close the project and the "challenge at hand" leaving less room for ideation thereby compromising from the outset the ideal innovation process

The general argument will be exemplified and concretized by the 10ECTS course Experts in Teams (EiT) mandatory to all fifth semester students on any engineering program at the University of Southern Denmark.

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Abstracts/Papers
Active Poster Session
Tuesday 14.50 - 16.10
Room 2.0.08
Theme: Activation and Motivation

Time	Room 2.0.08 Theme: Activation and Motivation
Introduction **14:50-15:00**	
Round 1 **15:00-15:10**	Certainty-based marking: Student behavior in multiple-choice exams. *Thomas Nielsen, Per Thorsen*
Round 2 **15:15-15:25**	TEACH FOOD – developing a teacher's community of practice. *Lene Duedahl*
Round 3 **15:30-15:40**	Student to student teaching in robot electronics course. *Martin Skriver, Anders Stengaard Sørensen*
Round 4 **15:45-15:55**	
Discussion **15:55-16:10**	

Certainty-based marking: student behavior in multiple-choice exams

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ABSTRACT

Keywords – Certainty-based marking, student self-assessment, multiple-choice exam

Please indicate clearly the type of contribution you are submitting: ___ hands-on, ___explore, _X_poster.

Background: In two engineering courses at 1st and 3rd semester, respectively, the summative assessment grading included a multiple-choice (MC) exam consisting of three time-separated parts through the course. The separation of MC exam parts additionally allowed for formative assessment. Correct and incorrect answers gave positive and negative points, respectively, with magnitudes such that random or guessed answers would approach zero points total. All questions had the answer possibility of “do not know”, which counted with zero points. This was a simple implementation of certainty-based marking (CBM) (Gardner-Medwin, 2006), (Adams & Ewen, 2009). The answer choice was intendedly influenced by self-assessed certainty, but also unintendedly by personality (Gardner-Medwin & Curtin, 2007). The aims of this study are to analyze existing test results and evaluate whether groups of students did not behave optimally in this decision-making, and to improve exam information and formative feedback between MC exam parts.

Explanation: The in-class activities consisted of theory and problem solving aligned with the assessment, and the MC exam parts assessed recently covered material. This continuously motivated student activity and learning during the course. Compared with traditional open-book exams, the MC exams had large numbers of questions (n = 18 and n = 12, respectively), and no solution strategies but only final answers were assessed, which was an argument for CBM. The students were instructed to carefully self-assess certainty when answering the questions. Practice MC quizzes were available for each lecture with questions spanning the intended learning outcome and training students for the exam method. Following each exam part, students received feedback on numbers of correct and wrong answers. Despite exam preparation and formative feedback, students may not have behaved optimally in the exams. Existing results form a large data set with many students and semesters. The 1st semester course (n > 200) covered more study lines, a subset of which included the 3rd semester course. Analysis of these data may identify problematic exam behavior, which improved exam information and formative feedback could prevent.

Set-up: Analysis of data from the two courses will be performed to address: 1) The use of “do not know” vs. wrong answer compared with final result (scatter-plots for visualization and relevant correlation and possibly cluster analyses); 2) Relationship between behavior on 1st semester and presence on 3rd semester; and 3) Comparison between study lines on 1st semester. The analysis may also address: 4) Comparison between behavior in the three exam parts in the 1st semester course and 5) Inter-semester results for same course.

Expected outcomes/results: The analysis will clarify whether students made best use of the answer possibilities in the MC exams or if particular groups of students did not. Based on the results, exam information and formative feedback will be improved accordingly in the future.

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TEACH FOOD – Developing a teacher's community of practice

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ABSTRACT

The National Food Institute (DTU FOOD) at DTU teaches and educates engineers for the food sector, the public authorities and the research communities. To meet these objectives faculty needs to be at the forefront of food science as well as in teaching and continuously develop the approach to how to teach. Learning environments with suitable student challenges requires devoted and involved faculty members, who continuously develop their competences in teaching. At DTU FOOD the faculty consists of scientist in a broad range of disciplines and cultures. TEACH FOOD was established to promote and enhance the development of community of practice, i.e. a Professional Learning Community (PLC) focusing on optimizing the learning outcome of the students. To achieve this, a 1½ residential seminar for all teachers was arranged. In the first seminar 76% of the teachers and the head of institute participated. Five core activities were identified and a series of half years seminars were started focusing on challenges in every day teaching experiences. The participation of DTU FOOD faculty members in the internal DTU conferences about teaching and learning has increased from 3 to 11 since the start of TEACH FOOD. These activities illustrate the extended willingness to discuss teaching and learning as well as share experiences from teaching at DTU FOOD exemplifying the growing PLC.

Keywords - Professional Learning Community, exchanging and sharing teaching experiences, development of teaching

I INTRODUCTION

DTU teaching structure

The Technical University of Denmark (DTU) educates around half of all engineers in Denmark. It is a single faculty university with 23 institutes and one centre (Centre for Oil and Gas – DTU). DTU has three campuses with the main campus in Lyngby. At DTU education in Bachelor of Engineering (B. Eng) (17 programs) and Bachelor of Science (B.Sc.) (18 programs) and Master of Science (M.Sc.) (28 programs) are taught. The B.Eng. programs are aligned with the international teaching concept CDIO (Conceive-Design-Implement-Operate) (Crawley et al 2007) where a predefined study plan is given with little flexibility for the students, to ensure a complete integration of CDIO. For the B.Sc. and M.Sc. about a fourth of the course can be chosen individually.

At DTU students have approximately 20 teaching hours a week and are expected to devote around 45 hours a week for their study corresponding to full time study. DTU have introduced the “red dot project” (Hansen, C.T. et al 2014) transforming students from pupils to students acknowledging their responsibility for own learning. DTU support cross-disciplinary projects where students work as engineers solving reel life problems. This is called Blue Dot (Blue Dot, 2017). Blue Dot projects are extra curriculum activities where knowledge is put into action creating reel products that can be tested. The learning objectives of Blue Dots are to work independently and creative using principles of engineering and theories based on up to date methods.

DTU course evaluation and teacher training

All courses are evaluated by students at the end of the course, after exam and during the course. The two first evaluations are sent to the institute study board and commented; the last is used for adjustment of courses during the semester. At many institutes the evaluation function as a quality assurance of teaching and learning.

All teachers at DTU have to take a mandatory teacher training programme (UDTU) in order to become associate professors or have full course responsibility. This is given by LearningLab DTU (DTU LLab). DTU LLab is the main support function on teaching and learning and aim at inspiring and support teachers, students and management at DTU. DTU LLab contributes to development of the quality of study programmes, teaching and learning at DTU and draws on a large network both in Denmark and internationally (LearningLab 2017). Teacher’s training and teaching development at DTU is based on the idea of “Scholarship of Teaching & Learning”. In brief, this means that a faculty member works professionally with continually develop and improve own teaching practice and evaluate the outcome in order to understand how to improve. For staff with a long teaching experience at university level and which have been course responsible for some years but still are missing a structured training in teaching and learning “University Pedagogy for Experienced Teachers” (UP) exists and have the same objectives and content as UDTU. An educational coordinator at each institute trained by DTU LLab, coordinates the didactic training at the institute with special emphasis on newly appointed assistant professors, and make sure that they are enrolled at UDTU and are awarded an educational supervisor. The educational supervisors supervise and evaluate the new staff’s teaching qualifications and potentials with feedback to , DTU LLab.

Background at DTU FOOD

Ten years ago, research institutes in Denmark were merged into existing universities to enhance the teaching capacity at university. It was politically decided that DTU FOOD, should be merged into DTU, whereby researchers with little or no background in teaching was transferred to an educational institution hereby becoming teachers and here had the opportunity to be educated in new teaching principles by DTU LLab and experience teaching without prejudice and focus on old tradition in how to teach.

DTU FOOD teaches and educates engineers for the food sector, the public authorities and the research communities. The focus areas are prevention of disease and promotion of health as well as making it possible to feed the growing population and development of a sustainable food production. This creates a common domain for teaching and learning.

The strategic objectives for teaching at the DTU FOOD has since 2015 been to increase recruitment to the Master's degree in Food Technology and further development and optimization of the three existing study programs with high quality teaching. To meet these objectives faculty needs to be at the forefront of food science as well as in teaching and learning continuously development of all three education programs, namely the Master in Food Technology, the Bachelor of Engineering (Food Safety and Quality) and the Bachelor of Science (Food and Nutrition) based at Copenhagen University to recruit motivated students. Learning environments with suitable student challenges requires devoted and involved faculty members, who continuously develop their competences in teaching and learning (Vescio, V. *et al*. 2008).

TEACH FOOD

To face the DTU FOOD objectives and needs for faculty development, the director in 2015 set terms of reference. The TEACH FOOD project was initiated to strengthen the teaching at the institute. DTU FOOD faculty consists of scientist in a broad range of disciplines, embracing food aspects from technology, microbiology, toxicology, chemical analysis, nutrition to risk assessment.

TEACH FOOD was created to encourage discussion on teaching issues, study programs and to cooperate and improve the understanding of students learning. The overall aim for TEACH FOOD was therefore to create a community of practice (Wenger, E., 1998), i.e. a Professional Learning Community (PLC) (Vescio *et al*., 2008) focusing on optimizing the learning outcome of the students (Wenger, E. 1998). Communication among faculty members should also aim at development and optimization of the three study programs included at the institute. Inspiration for this work to create a PLC was gained from a similar, but not identical, project some years ago at the former institute of DTU Systems biology (Hellgreen *et al*. 2011).

Here an attempt to create an overview of present status is presented. By continuously focus on creating a community of practice at DTU FOOD, TEACH FOOD assume that deeper learning for students and improved knowledge sharing among the faculty will be the outcome, for the better of society.

II HYPOTHESIS/PROBLEM STATEMENT

DTU FOOD is faced with two important scenarios. The first scenarios are to change the given courses from traditional lecture based to courses with student involvement and – engagement. By changing the focus from the lecture to the students, changes are necessary and the teacher should be willing to "let go of control" leaving the responsibility for the learning outcome to the student (Ulriksen, L. 2014). This is in alignment with the DTU project red dot (Hansen, C.T et al 2014) where the responsibility for achieving deeper learning is transferred from the teacher to the students so they become capable students and not pupils for whom learning is connected to the teacher. The teacher's role is then transferred to be facilitators of learning outcome. To do so, changes are needed and modern teaching philosophy and methods should be used for enhanced learning and alignment of evaluation (Biggs and Tang, 2001). Furthermore, students will have to engage more active in the teaching when changes are made presumably leading to deeper learning. This framework will have to be established finally when the institute is moved to the central campus of DTU here in 2017, leading to a broader exchange of information and knowledge in faculty.

Secondly, DTU FOOD was merged with DTU now ten years ago. Before the merge teaching was not a primary focus area in the institute leaving teaching to be done, when time was available. This has now changed and a building of a society of teachers exchanging information concerning how to teach without fearing supervision is needed. Teaching is presently still something done individually with little knowledge exchange between fellow members of the faculty. This leads to a feeling of loneliness when dealing with problems as how to teach. Due to today evaluation of teaching is highly focused on the student perspective, the teacher can find him/her isolated and having difficulties in sharing problems encountered. By having focus on these two areas, we believe that deeper learning for students will be the outcome we hypothesize.

III THEORETICAL FRAMEWORK

Communities of practice are formed by people who engage in a process of collective learning in a shared domain, here as teachers working for student deep learning in DTU FOOD study programs. This group share a passion and learn how to do it better as they interact regularly (Wenger, E. 2006). Three characteristics are crucial for a community of practice (Wenger, E 1998):

1. The domain
2. The community
3. The practice

First, the community of practice needs a shared domain of interest as a defined identity (Wenger, E. 2006). The teachers at DTU FOOD share commitment to student learning and own teaching practice development throughout their daily teaching and general training at either UDTU or UP. This community differs from the established community of research which aligns with the line of command. Teaching is cross-disciplinary between the departments in the institute. By TEACH FOOD, we established the second requirement, the community, who shares interests in student learning and continuously practice development are pursued by joint activities, discussions, shared information and helping each other. This support the movement from “feeling alone” to being part of a shared community working for improved education. The final requirement with a shared repertoire of resources, experiences, tools and ways of addressing recurring challenges sums up to a shared practice. This will be established through knowledge sharing and discussions at DTU FOOD at bi-annual teacher seminars.

The perspective of communities of practice affects educational practices along three dimensions:

1. Internally. By designing track for progressing of learning visual for the students and create cross-disciplinary course where students from multiple study program solve real life scenarios leading to motivated students (see also innovation).
2. Externally. By close cooperation with students hubs of innovation (DTU SKYLAB, 2017) and extra curriculum activities that are align with study program given the student opportunities that can lead to a “Blue Dot” diploma (Blue Dot, 2017). Finally, all education at DTU has advisory groups including representatives of industry setting the framework for competences in the study lines.
3. Lifelong learning needs continuing interest from the students. The university is in this context only part of a broader learning system. The University is not the primary learning environment. That is life in itself and the university creating alumni networks, graduates retain contact to the established learning environment at the university, hereby creating a symbiotic network of knowledge exchange (Wenger, E. 2006). Using”Authentic Learning” in complex scenarios an entrepreneurial mindset will be created and focus will not only be on Start-Ups (Fayolle, A. and Gailly, B. 2008).

Few empirical data have documented that learning community's support student learning (Vescio et al., 2008). The most significant factor for student learning is teaching quality, which is improved by continuous professional learning (Hord, S.M. 2009). The concept of a PLC rests on the premise of improving student learning by improving teaching practice (Vescio, V. *et al* 2008). Research support the idea that participation in a learning community lead to changes in teaching practice. When PLC is created a common core group is often identified (Wenger, E 2006). At DTU FOOD, TEACH FOOD represents this.

IV DISCUSSION

TEACH FOOD was divided into 4 minor projects (see figure 1), one for each study program and one for pedagogical development and establishment of a PLC. The last one formed a Task Force with two study leader, and the pedagogical coordinator at the institute. This paper describes work in progress. Since the introduction in 2015, implementation of the focus areas has been done gradually and here we attempt to show evidence of the ongoing process and its effect on teaching and learning. Implementation of e.g. course changes is delayed due to the standard procedures. This focus will be on creating the PLC and how this has and will improve teaching at DTU FOOD.

The Task Force, a representative from Human Resources and a representative from DTU LLAb planned a 1½ days residential seminar for teachers. The institute director and 35emplyeees (75% of the faculty) participated in the first seminar, facilitating a collective reference for faculty. This first seminar encouraged teachers to talk together across scientific disciplines and the main part of participants experienced teaching develop from loneliness to exchange of experiences and knowledge. Identification of core activities in TEACH FOOD resulted in the following five main activities included in the project time frame on figure 2.

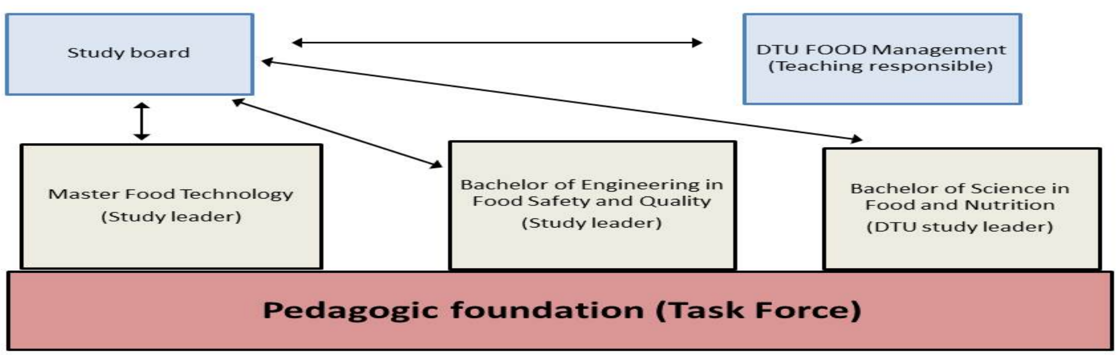

Figure 1: Organization of TEACH FOOD. At the top level we find management of course structure (study board) and resources management (head of institute). The three study lines are included in the middle and all are based on the pedagogic foundation. Responsibilities are in brackets.

Tools were identified from the discussions on teaching and learning at the seminar as a lot of case stories from industry and authorities available for application in teaching problem and case based (De Graaf, E. and Kolmos, A. 2003) .

Development of the study lines

The first crucial step (figure 2) for obtaining motivated and well-trained students were identified at the residential seminar to ensure transparent development of the three study programs. For each of the three study programs, the appointed study leader created series of meetings where content of courses and progression of teaching and learning are debated. Overlap in course content was identified and reduced. By creating individual communities of practice for each education program and involving all course responsible, information has been shared and understanding of the progression identified

The concept of a competence matric, obtained from CDIO (Crawley, E. et al 2007) was applied in M.Sc. for the development of two study specialization. At M.Sc. two courses are obligatory for all candidates. One of these courses (course no. 23101) has been adapted to include more broad and general competences essential for both specializations.

Competence matrices for personal and professional competences have been redesign in the B.eng. according to adjustment in the study program and each course responsible has given their contribution. This has been aligned to identify what courses contribute to the final learning objectives of the education. Increased average grade (from none to 5.9) for the 40 students indicate a raised interest in this study program from 2013 to 2016 among students.

For B. Sc. where study line responsibility is at KU, focus has been on creating a new important cross disciplinary course at the first semester and showing progression in food technology from this course to DTU courses taught on fifth semester.

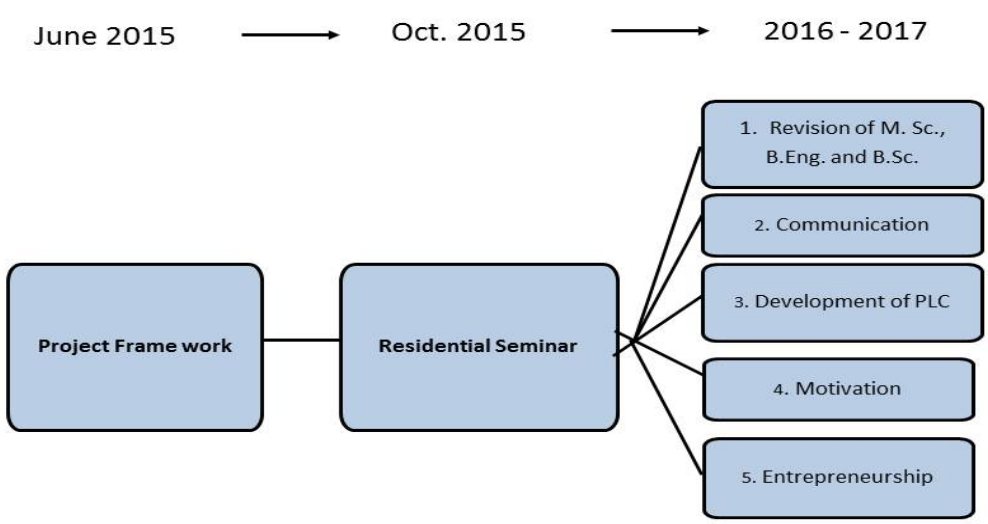

Figure 2: *Time frame for TEACH FOOD with the five core activities. The project will end in 2017 and the core activities will continue based on teacher motivation.*

Communication

The second activity identified were a need for a clearer profile for each study program, both internally and externally. The first result of the seminar was a name change for the B.Eng. from "Food analysis" to "Food safety and quality" hereby focusing on what the student learn and not what they do. Among the student this change has been achieved positively and they now understand the learning objective of the education. The name has made it easier for industry to understand what graduates can do and to differentiate these graduates from other education programs in Denmark. A course of fifth semester has been changed to sensory evaluation, a discipline requested by the advisory board for this education.

The teaching responsible at DTU FOOD has initiated a communication strategy for all study programs for students and future graduate employers. The work which will be launched in autumn 2017 has included involvement of study leaders, study board, task force and communication personnel at DTU FOOD.

Development of PLC

The Task Force has planned and coordinated biannual ½ day seminars for faculty members. For each of these meetings approximately half of the faculty participates including full professors. The shared interest in student learning and continuously practice development by these joint activities, discussions and shared information and knowledge were believed to establish a shared community of practice working for improved education at DTU FOOD (Wenger, E., 1998).

The first meeting was held in March 2016 with focus on exams. Representatives from DTU LLab introducing the theory followed by lively discussions on how to establish exam activities corresponding to learning objectives. The seminar inspired the teacher in food chemistry (23302) to change the exam to include overall open questions covering curriculum for the students to apply own examples prepared in advance instead of randomized questions with no prior idea on what is relevant from the curriculum. This increase the student learning due to an increased focused preparation for the exam at a higher level of Blooms taxonomy (Anderson et al., 2001). Results will appear in June 2017.

The second seminar in September 2016 included ideas and inspiration on student midterm evaluation with a practical example from a teaching situation. Emerging teaching technologies were presented with an example of development of a Coursera e-learning course. Active discussions and questions to the presenter indicated interest and willingness to adapt new technology and techniques in own teaching.

At the third seminar in March 2017 a discussion on career framework (Career Framework, 2017) and teaching portfolio development were discussed. Methods of quantitative measuring increased student learning were lively discussed with suggestion on use of e.g. exam grades, student pre- and post-tests as well as student course evaluations. The study board will look into if evaluations can be used. At the meeting it was suggested that extra curriculum activity required for UDTU participants could be used as an inspiration to the DTU FOOD teachers. The language in student approach was discussed as an attempt to establish practices in the community (Wenger, E. 1998). Teachers have some difficulties when addressing students as kinsmen/engineers (not so well trained) or pupils. Students often complain and feel that teachers look down upon them and do not recognize them.

Input for seminar topics has until now come from the Task Force. At the recent seminar faculty members started to come up with ideas on topics relevant for seminars in the future. Next seminar in September includes a presentation of use of personality evaluation for establishment of project groups at M Sc.

The DTU FOOD faculty members participating in the internal DTU conferences about teaching and learning have increased from 3 to 11 since the start of TEACH FOOD: Twice has DTU FOOD been among DTU institute with most faculty attendees. For the newly established “development of teaching” price a member of the faculty at DTU Food was the runner up in fall 2016. In addition at least two faculty members from the DTU FOOD contribute with presentations at the internal DTU conference every time.

Motivation

Involvement and increased focus from DTU FOOD management with visually recognition of teaching and teachers has increased focus on student teaching and learning at the whole institute. News on teaching are presented at quaternary presentations by the head of institute. Last year the task force members were presenting their motivation for teaching and learning at the yearly institute day. Since then, this group has experienced that colleagues have increased interest in teaching and learning realized as frequent questions and interest in e.g. student projects. It is acknowledged, that colleagues find it inspiring to teach. The recognition and visualization of teaching results in more motivated teachers indicated by even professors participate in teacher seminars and willingness to discuss teaching practices.

Entrepreneurship

Entrepreneurship should be included in relevant courses and be transparent for students. Courses part of the master education curriculum has been tweaked to result in a clear progression in innovation and entrepreneurship. These allow the student to take innovative ideas generated in courses at the beginning of their education and work with them through the following courses. Different courses in the study plan supplies the necessary engineering competences that can be put into play in this *wheel of innovation* that also include extra curriculum activities in cooperation with SKYLAB (SKYLAB 2017) and finalizing in Blue dot diplomas (Blue Dot., 2017). The number of students taking courses in this *wheel of innovation* has gradually improved from 78 in 2007 to 95 in 2016 and money has been granted by the Danish entrepreneurial fond to create a national competition in food innovation. The first student spin-off company was registered in fall of 2016

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VI CONCLUSIONS

A PLC is developing at the DTU FOOD. After increased focus from the DTU FOOD management and establishment of TEACH FOOD colleagues are after one and a half year already discussing teaching in the hall, at the cantina, and at the DTU FOOD biannual workshops with approx. 50% of all faculty members participating each time.

Study leaders have included relevant faculty in a systematic establishment of course matrixes similar to international CDIO principles for the study programs related to student competences and engineering abilities according to Blooms taxonomy.

Student evaluations of all courses at DTU FOOD are good and the community work continuous the development of knowledge based sharing and practices for student activation and evaluation. Measurement of student learning are ongoing and increasing in number.

Entrepreneurship and innovation has been integrated in courses both at the B.Eng. and M.Sc. and progression have been visualized by the wheel of innovation. Student participation in these innovations courses is gradually increasing.

Activities during biannual seminars at DTU FOOD and internal at DTU Teaching and learning conferences illustrate the extended willingness to discuss teaching and learning and share experiences from teaching at DTU FOOD. At the same time the DTU FOOD Director refers to teaching at her quarterly summaries and acknowledged teachers efforts and student satisfactory on courses and projects at the yearly summary. TEACH FOOD is developing and future perspectives are inclusion of other employees than faculty at DTU FOOD.

VII ACKNOWLEDGEMENTS

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BIOGRAPHICAL INFORMATION

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Håkan Vigre is the study leader of the Master education in Food Technology at DTU FOOD. He is course responsible and teaches several courses on risk assessment. He is part of Task Force for TEACH FOOD.

Pernille Hammar Andersson is educational consultant at Learning Lab, DTU. She works in the office for Study Programs and Student Affairs and is responsible for the mandatory teacher training program UDTU as well as other teacher training initiatives at DTU. She coordinates the network of pedagogical coordinators and work with a wide range of projects with aim to develop teaching and learning at DTU.

Lars Bogø Jensen is head of the Study board at the National Food Institute and study leader for the B. Eng. education “Food Safety and quality” He is course responsible for first year course on microbiology and food technology, part of the Task Force for TEACH FOOD, and participates in meetings in the DTU’s “netværksgruppe for universitetspædagogik”

Student to student teaching in a robot electronics course

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ABSTRACT (Poster)
Keywords – Student to student teaching, Teamwork, Electronics

I Background

The Masters program in Robotic Systems at the University of Southern Denmark accepts students with bachelor degrees in different engineering areas. This inherently causes problems concerning the varying academic levels. Almost half the students admitted for the robot electronics course fall 2016 were missing the prerequisites in physics, programmable electronic or classic electronics, to follow the course. Therefore, the challenge was in forming the lectures for the students to reach same academic level by the end of the course, without losing students for not being challenged nor for being over challenged.

II Explanation

Instead of having to teach the prerequisites for the course in addition to the course topics, it was chosen to utilize that more than half the students already fulfilled the prerequisites. Only theory from the course topics and the lab assignments were covered during the lecture presentation, so students needed to obtain the prerequisite knowledge elsewhere. To motivate student to student teaching, the lectures were based on laboratory assignments carried out in 3-4 person teams. The assignment descriptions intentionally provided only a lab setup howto and what to measure, it was left for the students to combine the assignment with the theoretical topic. This should serve as a subject for discussion in the teams but also to give a higher level of understanding of the theory in a physical system. Feedback for the journals along with a grading was provided by two of the other teams and a teacher. Reading journals from other teams supported the reader in understand the theory because of their similar skills in electronics. The grade was a symbolic indication for the students to know if a higher effort was required to understand the topic.

III Set-up

The students received a document every week, which typically contained a description of the topic, mandatory- and supporting reading materials. The supporting reading material presented the prerequisites to learn the curriculum. It was stated that the documents should not be studied into details but browsed through to get an overview, so they could be used as reference books. The lectures started in the classroom with discussing the evaluations for the journals from the week before, a short presentation of the new topic and an introduction to the laboratory assignment. The class continued in the lab where the teachers would answer questions and debating the assignment with the students. The students got half a week to hand in the journal and half af week to evaluate and grade the journals from two other teams.

IV Results

The quality of the journals increased dramatically during the 3 first assignments, after which they leveled out at a very satisfactory level. It was decided to cease the peer reviews of journals after the 5. Journal, in order to allocate more student resources to the lab work and their projects. The journals written by the teams represents hardly the weakest students in a subject, but the results from the exam should give a better success indication of the student to student teaching.
Feedback from some students said that the teaching form was time consuming, but they understood the content of the course and that they were confident prior to the exam.

Abstracts/Papers
Active Poster Session
Tuesday 14.50 - 16.10
Room 3.0.02
Theme: Interdisciplinary teaching

Time	Room 3.0.02 Theme: Interdisciplinary teaching
Introduction **14:50-15:00**	
Round 1 **15:00-15:10**	Training interdisciplinary hydrologists: differences between Chinese and Danish students. *Monica Garcia,* *Claus Davidsen*
Round 2 **15:15-15:25**	Bridging the gap in interdisciplinary engineering studies. *Tammi Vesth*
Round 3 **15:30-15:40**	Exploring Teacher's Thinking about Teaching & Learning. *Lars Bogø Jensen,* *Birgitte Lund Christiansen,* *Claus Thorp Hansen*
Round 4 **15:45-15:55**	Increasing the motivation of high school students to pursue engineering careers through an application-oriented active learning boot camp. *Kjeld Jensen,* *Mads Dyrmann,* *Henrik Midtiby*
Discussion **15:55-16:10**	

Training interdisciplinary hydrologists: differences between Chinese and Danish students

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ABSTRACT

Keywords – hydrology, interdisciplinary teaching, engineering, multicultural environment.

Hydrology has evolved from an applied engineering discipline to an interdisciplinary field. Major advancements are coming from collaboration between hydrologists and scientists with biological, chemical or social science backgrounds to tackle complex problems (Wagener *et al.*, 2007). However, the training of hydrologists with such an interdisciplinary perspective seems to lag behind (Ruddel & Wagener., 2014). The Master program in Water and Environment from the Sino-Danish Center (SDC) attracts every year students with science and engineer backgrounds. Hydrology is a building block for following courses, and in previous years, students with engineering bachelors tended to perform better. Our overall goal was to teach successfully hydrology to all students regardless of background. Specific objectives included: (i) assessing the role of different factors on learning outcomes (e.g. students' background or nationality); and (ii) test a more conceptual based learning approach (Treveler *et al.*, 2008) together with problem-based learning. We analyzed outputs from class surveys (pretest, student satisfaction), assignments and exams of a class of 21 students (14 Chinese, 7 Danish). Surprisingly, our results (Figure 1) showed that the learning outcomes with this set up were more dependent on students' country and teacher than on their engineering/science background. Students from a given nationality learnt significantly better/worse depending on teacher. This highlights how cultural differences affect learning outcomes and the positive effect of having different teachers/teaching styles within a course. Analysis of students' surveys will help to understand better our results to improve future learning outcomes for all hydrology students.

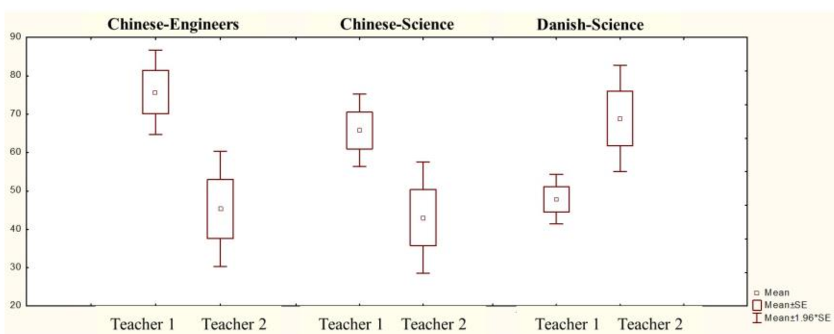

Figure 1: Mean differences and confidence interval ($p<0.05$) in learning outcomes (0-100) for student's nationality and background (Engineer and Science) stratified by teacher. SE is standard error of the mean.
Results from the study will be presented in this contribution as a **poster.**

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Bridging the gap in interdisciplinary engineering studies

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ABSTRACT

Keywords – Engineering, Interdisciplinary, Comfort levels, Fundamental changes in perception

Contribution type: Active poster

"Interdisciplinary studies", it rings well right? But how do you teach people two subjects at the same time? How do you bridge the gap in knowledge and basic understanding that exists between two fundamentally different technical fields? The field of bioinformatics, the fusion of biology and computer science, as well as input from the diverse disciplines of mathematics and statistics, physics and chemistry, and medicine and pharmacology, has long struggled with this challenge (Altman 1998, Goodman 2014, Machluf 2017, Pevzner 2009) in its attempt to educate people in these very different topics. The course described here aims to bridge this gap given a specific profile of students and time restrictions. At time of writing this course is planned to run in January 2017 but the effectiveness of the planning is yet to be evaluated.

The overall learning objectives for the course are to enable the students to design and perform a data driven experiment from biological data and write the experimental into a small scientific paper. Here, I will present a course designed for Master's level students in biotechnology who wish to start working with bioinformatics. Biotechnology, being the study of microorganisms in the context of industrial application, is traditionally a field involving complex laboratory skills, such as cloning and feature screening. The difference in biological knowledge between between biotechnology and bioinformatics is minor while the gap in technical skills is wast as bioinformatics requires the work with data analysis and programming, techniques that are not traditionally part of biotechnology (Tan 2009, Welch 2014, Wind 2008). This type of students has often shown signs of discomfort, insecurity and lack of overview when getting into this topic, as it is so far from their normal knowledge fields (Libeskind-Hadas 2013, Machluf 2017). The course uses flipped classroom and case based learning to help the students gain confidence in their abilities in a new field while showing them the context in which the knowledge is used.

The course is designed as an intensive 3 week course (8 hours per day, five days a week, 5 ECTS points) with lessons every day and a total of 4 classic lectures (45 minutes each). A flipped classroom approach is used twice (session of 5 hours each) to let the students investigate online data and analysis resource. These are supplemented with hands on technical assignments (3-4 hours each) and short fast paced projects in groups (6-8 hours per project, one project per week). The projects are case based, the students are asked to read a specific journal article, analyze the content and design their analysis inspired by it. The fast pace and short deadlines serve as a way to eliminate the student's opportunities to question themselves and lose focus. The students will work on 3 projects and will be changing groups for each, again, forcing people to deal with the project assignment more and each other less. The projects will be of increasing technical and analytical difficulty and will build on skills acquired in previous projects. The two first projects will be concluded with a presentation (15-20 slides, 15 minutes and analysis code/method) while the last project will be finalized by a scientific article style report and presentation (3 pages, 20-30 slides, 20 minutes and analysis code/method)

Formal assessment is performed based on the 3 projects (oral presentations, code, hand in of slides and written report, the written report is only for the final project) as well as handing in of code and notes from technical exercises. The students are given a chance to assess their own learning through peer assessment during class discussions of results and discussions between groups at the end of each project. Lastly, days of technical tutorials and discussions are ended with a small test which is then discussed the next day. The tests are largely based on the learning objectives stated for the day as well as for the technical exercises. This allows the teacher to stay on top of what is not sticking and gives the students the opportunity to evaluate their own progress.

The teaching format described here is in strong contrast to how this topic is generally taught, with heavy focus on teaching complicated technical skills in long and hard tutorial sessions. It is the intention that this new format will result in students with a higher sense of accomplishment and desire to learn more. This is crucial if biotechnology graduates are to take their place in the new world of microbiology and biotechnology, which relies on both biology and informatics students to engage and remain curious as to how these two fields can grow together (Machluf 2017, Pevzner 2009).

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Exploring Teachers' Thinking about Teaching and Learning

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Keywords – Teaching philosophy, teaching and learning, communities of practice, gamification

ABSTRACT
Professional practice in general is to a large extent based on tacit knowledge (Schön 1983). For university teachers, tacit knowledge includes knowledge about what works – and what does not work – when teaching a specific group of students a specific subject matter in a specific context.

Making tacit knowledge explicit is important for at least two reasons: For the individual it may facilitate a more conscious linking of lose impressions and observations from own teaching practice to general principles of teaching and learning, thus enabling a more systematic interpretation and development of own teaching (Mcalpine and Weston 2002). It is also useful – if not necessary - for communication with others about teaching and learning, e.g. when peer coaching less experienced colleagues, or sharing experience and collaborating on teaching development with colleagues. Teaching Portfolios are a well-known means for the individual teacher to develop a reflective approach to own teaching practice and the underlying values and presumptions, including a process of making tacit knowledge explicit (Smith and Tillema 2006). However, we see a need for methods for sharing, discussing and developing teaching philosophies in a collective process. The perspectives of introducing such methods are to support a team-oriented approach to teaching and to strengthen communities of practice (Wenger 2008)/ communities of learning among teachers.

So how can we do this? The authors have conceived and designed a game to identify and clarify teachers' values, attitudes and preferences related to their teaching. The core element of the game is a deck of cards each with a statement about teaching and/or learning, e.g. "Students must learn to dare to fail and learn from their mistakes", "What I teach is what students learn", and "Blackboards are an overlooked method of teaching". While the statements do not give the "solution" to what good teaching practice is, their purpose is to start a personal reflection.

During the game, the players go through an individual reflection process leading to the selection of a number of cards with statements each player find relevant and important in relation to the question "What is good teaching?" These are then ranked and discussed in a group of players who are asked see if some consensus can be reached and explore if they can identify common approaches to teaching and learning. This consensus may different from the individual player's choices.

We have facilitated game sessions at several occasions, among others: at an international engineering education conference, at an annual education day at a university abroad, and at a meeting for study leaders of Bachelor of Engineering programmes. We have collected documentation of the selection and ranking of cards in these sessions, and analysed the data. These data represent the involved teachers' individual preferences, and consensus reached within groups of players - preferences which may influence their teaching practice, consciously or unconsciously.

The data analysis has raised questions like:

- What patterns can be identified based on the cards that were selected, and the cards that were not?
- What kinds of attitudes towards teaching and learning do the selected cards represent?
- Which selections reflect teaching practices that support active learning?
- What types of statements have participants filled in on blank cards?

The active poster will present data collected and conclusions of the analysis. This will supplement the workshop at the ETALEE 2017 conference (Jensen, Christiansen and Hansen 2017) – that gives conference participants a chance to get a first-hand experience with the game – with giving an opportunity to discuss the outcome of having played the game and help us with input to the further development.

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Increasing the motivation of high school students to pursue engineering careers through an application-oriented active learning boot-camp

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ABSTRACT (poster)
Keywords – outreach, boot-camp, drones
The main objective of this work is to increase the motivation of high school students to pursue a career in engineering. This is achieved through a 3-day university boot camp with a high focus on applying theoretical knowledge to real world problems, technology development and working in teams. The learning outcomes are therefore both related to academic/technical topics and to career decisions.

The boot-camp is planned for second and third year high school students and has been developed for and co-funded by a project named “The Maritime House”. The students are presented to a problem concerning oil spills floating on the water surface at sea. Working in teams of 4-5 students they develop a solution for detecting oil spills using a drone carrying a video camera. The project work is divided into exercises that are spread across the three days. The exercises support the key challenges of the solution: Developing a drone capable of flying; developing a camera which can be remote controlled by the drone pilot; developing image processing algorithms capable of detecting artificial oil spills; flying the drone outdoor recording videos of artificial oil spills; Post processing of the recorded videos to validate the detection of artificial oil spills.

The exercises are closely related to key elements from the high school curriculum in mathematics and physics, and are designed to let the students experience the satisfaction of being able to apply theoretical knowledge previously learned in high school to develop a solution. A description of each exercise are handed out to the students and introduced by the teacher. Most of these introductions include a recap of the related theory and a few quick calculation exercises to emphasize the relationship with the problem at hand. Materials used for the drone and video camera are low-cost, and the software used is open source. This enables the students to continue working with this after the boot-camp.

The boot-camp has so far been conducted 5 times for third year students from technical high schools. At each boot-camp the students have worked with a high level of enthusiasm, planned free time in the evenings has been used voluntarily by the students to complete the exercises. It quickly became clear, that an important prerequisite for keeping the students attention and activity level is that they to a large degree are capable of completing the exercises including getting the drone flying. To this end most exercises have been designed to enable the teacher to support the teams by providing additional elements of the solution as time progresses.

At 2 out of the 5 boot-camps the students answered a questionnaire. Among other questions they were asked to rate on a scale of 1-5 how *learning*, how *exciting* and how *fun* the boot-camp has been. The average ratings of all answers are 4.3, 4.6 and 4.7 respectively. One high school teacher has reported that out of two boot-camps where he and in total 25 students participated, 6 students (24%) has subsequently applied for a bachelor in robotics at SDU.

Based on this limited data it is concluded that the boot-camps appear to be a succesful outreach activity. Further analysis is needed to evaluate to what extent the main objective and learning outcomes have been achieved. The authors would like to thank Mathias Neerup, Martin Skriver, Miichael Nielsen and Rasmus Stagsted for their contributions to developing and testing teaching materials, and UAS Test Center Denmark for providing access to their test facilities at HCA Airport for the flight experiments.

Abstracts/Papers
Active Poster Session
Tuesday 14.50 - 16.10
Room 3.1.15
Theme: Student initiated work

Time	Room 3.1.15 Theme: Student initiated work
Introduction **14:50-15:00**	
Round 1 **15:00-15:10**	Practical student activation strategies and activities in engineering education. *Dylan Cawthorne*
Round 2 **15:15-15:25**	Engineering conferences – An innovative course for master students in engineering. *Matthias Neef,* *Claudia Fussenecker,* *Thomas Zielke*
Round 3 **15:30-15:40**	Teaching game programming using video tutorials. *Gunver Majgaard*
Round 4 **15:45-15:55**	
Discussion **15:55-16:10**	

Practical student activation strategies and activities in engineering education

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ABSTRACT

Keywords **-** student activation, engagement, active learning, hands-on learning, e-learning

Please indicate clearly the type of contribution you are submitting: **poster**

I BACKGROUND

Bachelor-level engineering courses at the University of Southern Denmark typically consist of one, 3.5-hour class session per week. This format offers advantages and challenges: there is time to go deep into complex topics, but it can be difficult to keep students activated during the entire class period.

Research question: which practical student activation strategies and activities are most effective in maintaining student engagement throughout a 3.5-hour class session?

This research question has been tested in the context of various engineering courses, including: Composite Materials and Manufacturing, Materials and Processes 2, Product Development and Innovation 3.

II EXPLANATION

These strategies and activities are designed to contribute directly to active students. Several activities from *Activating Strategies for Use in the Classroom* (Lewis & Thompson, 2010) are utilized.

III SET-UP

Activation strategy means planning classroom activities so students will be engaged and stay engaged. Strategies tested included switching media types every 15 minutes (lecture, video clips, hands-on learning etc.), utilizing short in-class assignments ('think-pair-share'), and getting out of the classroom (visits to companies, as well as other organizations and faculties on-campus).
Activation activities tested included the use of video clips, hands-on learning, company visits, 'think-pair-share', the 'alphabet game', 'how do you…', and the 'illustration/cartoon' game.

IV OUTCOMES/RESULTS

All of the activation strategies have performed well, based on student feedback and student performance. The best activation activities are the use of video clips, company visits, and the 'think-pair-share' method for in-class assignments and discussions. In one class utilizing these techniques, 95% of students rated the course positive or highly positive, and had the following comments:

'…even though the classes last for four hours his teaching method is very dynamic so students don't lose focus on the lecture.'

'Good teaching, good videos that help understanding'

'I think the course is nicely divided into teaching and hands-on. I like the opportunity to visit companies and the way the course i structured so group work can be done in class time.'

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Engineering Conferences - An Innovative Course for Master Students in Engineering

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ABSTRACT
A course called "Engineering Conferences" is presented that the authors have developed and installed as a mandatory part of the curriculum in Master programs for engineering students. The idea is to go beyond teaching the standards of academic writing and skills for working with scientific publications. By using a learner-centered approach, we get the students engaged in typical activities around an active attendance of a real conference. They write a paper complying with common academic standards, submit the paper and review submissions of their fellow students. Students also produce a poster and have to defend it in a poster session held publicly on campus. In this article, we present our rationale to develop the course and our results from the first semester teaching this course. This includes the presentation of useful resources for teaching and organizing scientific publishing as well as our reflected learning experience regarding the student's understanding of significance for scientific publishing.

Keywords - active learning, challenge based learning, liminal space

I INTRODUCTION & CONTEXT

When developing the curricula for three new master courses in engineering it was decided to include an introduction of students to publication of research in general and particularly to the world of engineering conferences. It was clear from the beginning, that this course should go beyond the kind of skill training which deals with limited details of the publication process in a classroom and leaves out the fun part: the rewarding conference event. With this in mind, the new course was called "Engineering Conferences". On the way to a suitable course concept, the following limitations had to be taken into account: Students admitted to the master course are a heterogeneous group with respect to their Bachelor degrees, their nationalities and their experience with scientific research. Furthermore, resources of the faculty are limited, i.e. an annual real conference with an open call for papers cannot be organized and a participation in an existing conference can neither be guaranteed nor sponsored for every student.

Starting from these initial considerations, we set out to examine five different aspects of teaching and learning as applied to publication of research and developing scientific communication skills.

Aspect #1: Undergraduate conference concepts and research journals

The opportunity for publication of research at an undergraduate level exists for a long time, especially in English speaking countries. The National Conference on Undergraduate Research (NCUR) has been running in the United States of America since 1987 and has been copied by numerous other countries, such as the British Conference on Undergraduate Research (BCUR). The latter is held annually since 2011 and has been surveyed in a study among 90 student participants across three years by (Walkington *et al.* 2016). In the same way, quality controlled publication of research is possible for students by submitting their work to undergraduate research journals, which are also available from institutional to international levels. These approaches have at least four features in common, namely: The organization and review-process is similar to professional conferences and journals, the orientation is multi-disciplinary, the event or process is fully run by students and the latter act on a voluntary basis as author and/or organizer.

The last point implies a natural selection process, which distinguishes the participants from the average student in an undergraduate course, where not everybody can be excellent or motivated by good example. However, with our course, we aim for no less than a better communication culture between professionals across disciplines and social divides. To achieve this, we expose all our master students to the basic standards of peer-reviewed research and provide the opportunity to present their own work on a conference-like level.

Aspect #2: Existing publishing resources and related courses for undergraduate students

At an institutional level, various approaches to learn and train the written and oral presentation of scientific work can be found. Commonly, the required skills of students are developed throughout continuous assignments to write lab reports, project documentations and, finally, the Bachelor thesis. Ideally, the student develops his own style and skills with respect to authorship by learning from various staff members, but the learning process itself and its result or success is rarely made explicit or guided. Exceptions presented by those with disciplinary knowledge are both available and inspiring, see e.g. (Dirrigl & Noe 2014). However, ambitious and valuable courses like “Writing your thesis” or “Presentations for engineers” are often offered on a voluntary basis and outside the faculty, see e.g. (Leydens & Olds 2007, Neilson 2013). This can convey misleading messages with respect to developing a self-confident authorship: "Writing is only an add-on for the best" (they usually book the course first) and/or "I am doing this only to get rid of my defects, but it has nothing to do with my professional development as an engineer". This situation has been observed and evaluated by (Durfee *et al.* 2011), who consequently developed a writing-enriched curriculum from within the faculty at the University of Minnesota.

For the development of our own approach, we argue that the emergence of scientific communication skills should not only be an explicit and integral part of the curriculum but must be developed as a competence from within the faculty.

Aspect #3: Relation of (disciplinary) research and teaching in general and with respect to undergraduate education

While research and teaching have at least co-existed if not cross-fertilized each other for centuries, it has been suggested and surveyed that there is little statistical evidence for a correlation between the two (Hattie & Marsh 1996). The perception of the relationship between research and teaching is dependent on the current orientation of the institution(s) as well as the history of universities and is thus changing with time (Brew 2006). It can therefore be argued, that the increased awareness for competences based learning outcomes in the development of curricula, as opposed to technical knowledge production, has spread the idea to design research-oriented undergraduate courses, see e.g. (Healey *et al.* 2014) or instruction – despite earlier perceptions of the relation of research and teaching. The move is both not new and natural: While looking for more complex, interdisciplinary challenges, which can be dealt with by groups or students and which are at least partly related to their field of study, teachers and students may find themselves simulating if not carrying out research. While the value and the judgement of research quality in general is currently challenged by governmental influence to develop high-level research in selected universities, see Jenkins & Healey 2010), it may be helpful to remember the medieval meaning of the word “research”. It remains the act to “go about seeking”, see (Merriam Webster Inc., n.d.), and there is no shortcut for students from being involved in this activity to become self-reliant learners. At the latest, students gain some sort of this experience during their Bachelor thesis, which therefore can be regarded as research in their field of study – regardless of quality and outcome. In a nutshell, research is learning, and learning is research and should be supported by teaching.

Thus we regard the Bachelor thesis of each student as an existing piece of research and take it as a starting point for our course module on scientific publishing. According to (Healey & Jenkins 2009), our concept follows a research-based approach. This means it is more focused on the research process rather than on the research content – which has already been dealt with during the thesis – and it addresses students as participants rather than an audience.

Aspect #4: Active learning in engineering education

From the above paragraphs it can be concluded that personal engagement in research is an activity allowing students and university staff to meet as learners. However, active learning in higher education can appear in a lot of different forms other than carrying out research and has seen a strong increase in related publications since the turn of the millennium (Lima *et al.* 2017). Consequently, the number of available tools and resources is vast, calling for guides which map and/or navigate through current best practice, see e.g. (Eddy *et al*. 2015). Some of the concepts are often mentioned in the same breath as active learning such as the flipped classroom, and problem or project based learning (PBL). The appreciation of active learning is influenced by the personal learning biography as well as by what we currently know about how learning works in general. A sketch of the philosophical and pedagogical underpinnings of active learning in engineering education is drawn by (Christie & de Graaff 2016), while others have delivered ample proof for the effectiveness of active learning, see e.g. (Prince 2004).

For our own course, the aspect of active learning led to the following conclusion: Participation in an engineering conference requires that the author actively prepares, revises and presents her/his paper or poster. When implementing this as a goal for a master course, the publication process becomes a project with the author as the manager of her/his success, thus placing the responsibility for the associated learning experience into the hand of the student. Despite the overall PBL approach, the supporting course units are also suitable for group exercises and other interactive learning elements.

Aspect #5: The transition phase - from institutionalized learning to learning on the job

While higher education should generally equip students for their future career, it is particularly apparent for most of those enrolled in a master course that "real life" will start soon. This is no reason for students and teachers to become sentimental, but fertile ground for enhanced learning experiences.

First of all, the way of learning changes anyway: After university, life-long learning becomes much more informal and self-reliant - as it was before school enrollment. The alumna/alumnus will have to change from the consumer of packaged learning goods to the hunter for life-sustaining nutrition, as "experience and education cannot be directly equated to each other" (Dewey 1938). So why not help students *before* leaving university to become self-learners (again)?

Secondly, advancing into new and open terrain may look like trouble ahead but is often the threshold to new advances in learning. This is well described by (Meyer & Land 2005) with the threshold concept of learning, which can ultimately "*lead not only to transformed thought but to a transfiguration of identity and adoption of an extended discourse"*. This transformation can be stimulated by the creation of liminal spaces. (Walkington *et al.* 2016) have shown that undergraduate research conferences are perfect opportunities to open such spaces, helping students to *"reformulate their taken-for-granted frames of meaning by engaging in critical reflection, through a process of dialogue with others. Such dialogue is a central element of transactional communication."*

Finally, this underlines that advances in learning are often related to advances in communication skills, leading to changes in the perception of identity. This is most obvious in the development phase of a child while acquiring the ability to speak but equally valid for other opportunities where the capability to appropriately express oneself is expanded.

This justifies the preparation of the following challenges for the master students:

1. Implement a course design different to the classical concept of lecture, exercise, lab testing or project etc. The feeling, not to know what to expect, and the experience that engineering-specific

knowledge is not in the focus pushes students beyond their comfort zone (opens liminal space for new learning experiences).

2. Work with language in new forms: Let students explore the language of the scientific community. Use English as a means of instruction (EMI) with non-native speakers and as the standard in international scientific communication. Expose students to the structure and form of scientific discourse. Introduce them to new tools and means to express her/himself.
3. Bestow self-authorship upon the learner (facilitates transactional communication for the development of personal and social judgement and responses)

II COURSE CONCEPT & CONTENT

While preparing for the accreditation of three new master courses, the faculty decided to give the writing and presentation part of the final thesis more emphasis. The module we developed accordingly is designed for 30 master students per semester, while the students are free to enroll to the mandatory course in any of their regular three semesters. Participants are students of a medium sized engineering faculty (approx.. 1500 students) of a University of Applied Sciences in Germany. Since two of the degree courses involved are international programs, we have a share of overseas students, English as a means of instruction (EMI) is set. Six credits can be earned according to the European Credit Transfer Scheme (ECTS). All facts and figures are summarized in Table 1.

With our concept, we aim to address at least some of the seven high-impact educational practices identified by (Kuh 2008). Most obviously, our course meets the need for writing intensive courses, but also underline the value of undergraduate research and includes collaborative assignments. The resulting learning outcomes and the related challenge-based learning opportunities in alignment with the background outlined in the introduction are presented in Table 2. They do not in itself excel beyond state-
of-the art courses in academic writing or scientific publishing. However, the simple approach towards achieving those aims is turned into the following project: You have already earned your first credits with research (bachelor thesis), now prepare to communicate your findings to your peers in the scientific community and go public. Your admission ticket is a research paper and you will be rewarded for your poster (see Figure 1). This cannot be better accomplished than by preparing for an engineering conference. Ideally this would be an exercise involving a real conference, as described by (Watkins *et al.* 2014), for example. For obvious practical reasons, we opted for a simulation of an engineering conference, which exhibits all elements of scientific publishing in a timely order. In more detail, this concept is presented as

Table 1: Course details - facts and figures

Module Name	**Engineering Conferences**
Master Courses	Mechanical Engineering (3 semester) Simulation and Experimental Technology (3 semester) International Business Engineering (3 semester)
Module Type	mandatory
Credits	6 ECTS
Language	EMI (English as a means of instruction)
Exam Elements	paper, two paper reviews, poster presentation
Semester	first, second or third
Number of participants	approx. 30 per semester (60 per year)

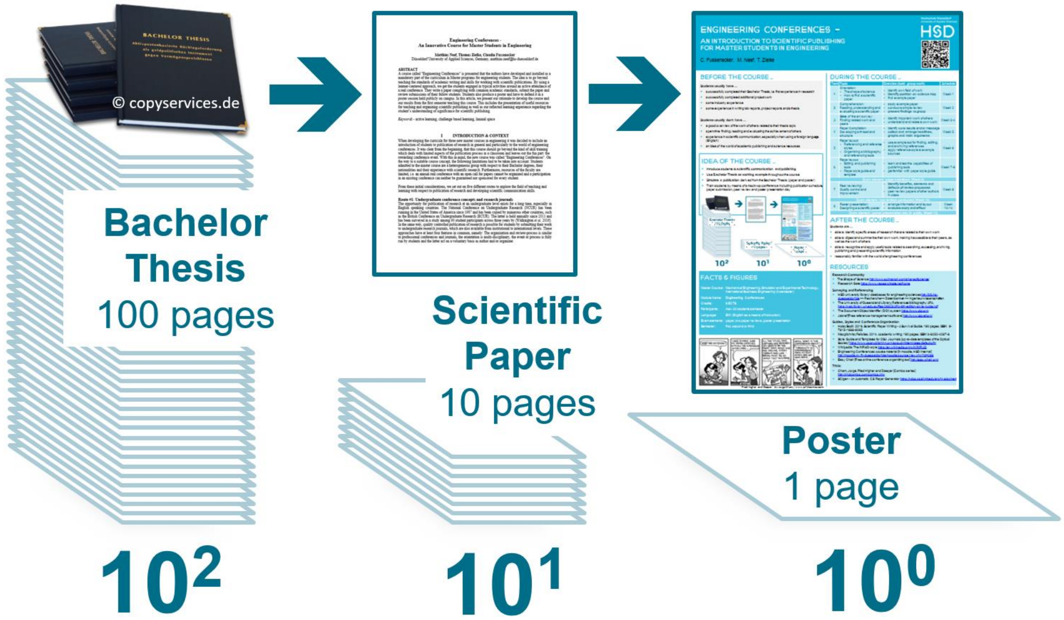

Figure 1: Reducing page numbers by two orders of magnitude: Evolution of key findings and the core message from thesis to paper to poster

the basic working instructions for the participants:

1. take your bachelor thesis as a starting point
2. re-visit your thesis as research and relate it to research in the relevant scientific community
3. condense, compress and compile the main arguments of the thesis , consider related work, and produce a paper
4. walk through a simulated publication process from abstract over paper submission and peer review to poster presentation in the form of a mock-up conference
5. go public: course finishes with a poster presentation day held in public on campus

Following the storyline of an engineering conference, we identified several tasks to help the students in the process of preparing their research for publication. This also means that we as the teachers are becoming help agents in the publication project with the students managing their own project and learning experience (directing towards a flipped-classroom concept). With reference to the introduction (Aspect #2), it should

Table 2: "Engineering conferences" - learning-outcomes and opportunities

Learning Outcomes, directly related to scientific publishing	Related challenge-based learning opportunities
After participation in the course, students are … ▪ able to identify specific areas of research that are related to their own work ▪ able to recognize and apply useful tools related to searching, accessing, archiving, publishing and presenting scientific information ▪ able to digest, evaluate and summarize their own work as well as the work of others ▪ able to make their own work accessible to their peers ▪ reasonably familiar with the world of engineering conferences	▪ How do I pose a problem precisely? ▪ How do I raise and defend a hypothesis supported by facts and arguments? ▪ How do I present my main arguments within limited boundaries (space, time, level of interest and knowledge of peers)? ▪ How do I relate my work to the work of others? ▪ How do I excel in a larger group?

be highlighted again that we are able to approach the students as researchers and as experts with disciplinary knowledge in engineering on a peer-to-peer level and not solely as instructors for communication skills. It should be noted, however, that at the same time we remain the examination board, which naturally limits the level of student-teacher proximity and which is a distinctive disadvantage over the "real" conference experience.

Each of the tasks on the road to complete a paper and a poster comprises an introduction by the lecturer, followed by one or more exercises (see Table 4). This can be exercises in class or additional homework that has to be prepared for the next sessions. The homework exercises deal with aspects directly related to the preparation and emergence of the final paper serving as supportive suggestions of how the compilation of the paper can be tackled in a useful order. Special care was directed at the design of group work exercises: Students develop content and gain learning experience ,with the lecturer standing aside serving as moderator (see exercises in bold face of column 3 in Table 4). As an example for these active learning exercise, the course starts with an "elevator talk" (Annesley 2010): Each student has a few minutes time for preparation and then has to explain the topic of her/his bachelor thesis to another student within two minutes. This exercise is repeated before the students have a chance to reflect their experience. For most of them, it is the first time taking about their thesis topic in English in a very limited amount of time with the clear aim to convey a message (pushed beyond comfort zone).

Table 4: Course Outline: Tasks and Exercises

Task	Tasks	Exercise (**bold face**: group work)	Schedule
1	Orientation: ▪ The shape of science ▪ How to find a scientific paper	▪ **"Elevator talk": my thesis is about …** ▪ identify own field of work ▪ **identify position on science map** ▪ find example paper	Week 1
2	Comprehension: Reading, understanding and evaluating a scientific paper	▪ study example paper ▪ conduct a simple review ▪ **present findings to group**	Week 2
3	State-of-the-art survey: Finding related work and peers	▪ identify important work of others ▪ understand and relate to own work	Week 3-4
4	Paper compilation: Developing a thread and structure	▪ identify core results and/or message ▪ **collect and arrange headlines, graphs and main arguments**	Week 5
5	Paper layout / references: ▪ Referencing and reference styles ▪ Organizing a bibliography and referencing tools	▪ use example tool for finding, editing, and archiving references ▪ apply reference style to example sources	Week 6
6	Paper layout / style: ▪ Editing and publishing tools ▪ Paper style guide and template	▪ learn and test the capabilities of publishing tools ▪ get familiar with paper style guide	Week 7-8
Exam element: paper submitted (Week 8)			
7	Peer-review: Quality control and improvement	▪ **identify elements, stakeholder, effects and defects of review processes** ▪ peer-papers of other authors in class	Week 9
Exam element: two reviews conducted (Week 10)			
8	Poster presentation: Designing a scientific poster	▪ arrange information and layout ▪ **evaluate story and effect**	Week 10-14
Exam element: poster presentation day (in public, Week 15)			

Before the students are asked to re-visit the content of their bachelor thesis, we make sure that they spend a considerable amount of time to orient oneself in the scientific community and to identify and digest related work of others. In many cases this is a new experience for the student: Her/his bachelor thesis may include references to methods described in textbooks or technical articles, but a deep survey of latest international scientific efforts in her/his field of work were not part of the task given to her/him when starting the thesis (for comments on this situation see the conclusions).

As can be seen from Table 4, a lot of emphasis during the first half of the course is directed at the orientation before some formal details of the publication process are introduced. Students are repeatedly encouraged to chew on the summary, main results and thread of their thesis, e.g. by oral short presentation, mindmap of the important figures etc., before molding everything into a given (real) paper template.

To model the paper submission and review process, we use the free web-based conference management system EasyChair (easychair.org), which allows us to set deadlines, upload papers, define roles such as authors, reviewers and chairs, organize reviews etc. This is not only easy to use for teachers and students but also a real conference standard. After the paper submission, students are requested to conduct two reviews of their peers in class. This includes filling out a review form, which requires to state a reason for each rating and also the upload of the reviewed paper with the reviewer’s annotations. If nothing else, the latter is an important and visual verification of the engagement of the reviewer with the papers. In real life, reviewers are volunteers, highly motivated, and usually concerned about their scientific reputation. For the student reviewers, we have not yet found an optimal incentive being both highly effective and practicable for our course.

The last part of the course is dedicated to the preparation of the poster. The poster presentation day is the final event of the course and takes place in the main entrance hall of the faculty building (see Figure 2). While each student has to deliver a two-minutes keynote on his/her research topic, the others are free to browse the final product of their peers or to answer questions of visiting faculty members and students. Both poster and keynote are assessed on the spot by the lecturers resulting in the final grade for the course.

A few results from the 1st semester of the course with 36 participants give an indication of the examination process: The submitted papers were rated by the students (two reviews per paper) including the following aspects: originality and significance; technical soundness, clarity, structure and length, language and writing, figures, references. The average rating across all these categories was 86%. Additionally, the reviewers had to give an overall rating, which yielded an average of 80%.

Figure 2: Impressions from the poster presentation day

Credits for the course were earned by the poster presentation, rated by the teachers. The evaluation was based on the performance in the following categories: header, main message & idea, figures & tables, conclusions, references, layout & structure for the poster plus message & delivery for the oral presentation. The average rating was 92%. The good quality of the presented posters supports the idea to qualify, select and sponsor students for a real conference participation as an additional benefit from the course.

III EXPERIENCE & REFLECTION

With the experience from the design and the completion of the first course semester, we revisit the aspects we examined in the introduction for reflection.

Adaptation of undergraduate conference concept

We succeeded in organising and applying the conference concept in the form of a paper submission and poster presentation as a compulsory master course module for 30 students in an engineering master's degree. The setting provided both an underlying story for the project of producing a research publication as well as an open space to present the results outside the classroom. During the course, we observed a significant increase of activity among both faculty staff and students in social networks for researchers and scientists. This positive side effect of the course was boosted by the final event of the poster presentations which vividly enhanced scientific and informal exchange within the home faculty and its neighbouring faculty. It now stands as one of the rare events in the curriculum where the result of learning is proudly made visible outside the classroom. Students were very positive about this culminating event, providing personal satisfaction and success beyond good exam results, despite the effort required to earn credits (see Figure 3).

However, we are well aware of the limitations of our mock-up concept – the real conference remains the ultimate experience: Voluntary participation and a rigorous selection process are key drivers to self-motivation and "one-off" experience. Additionally, the conference location outside the home institution is virtually promoting the step beyond a threshold out into the open and unknown, yet protected learning space filled with enthusiastic peers.

Appreciation of scientific writing resources

While preparing the material for the various tasks, we were both overwhelmed and positively stimulated by the vast resources available on scientific writing practices and research communication. As an example, we

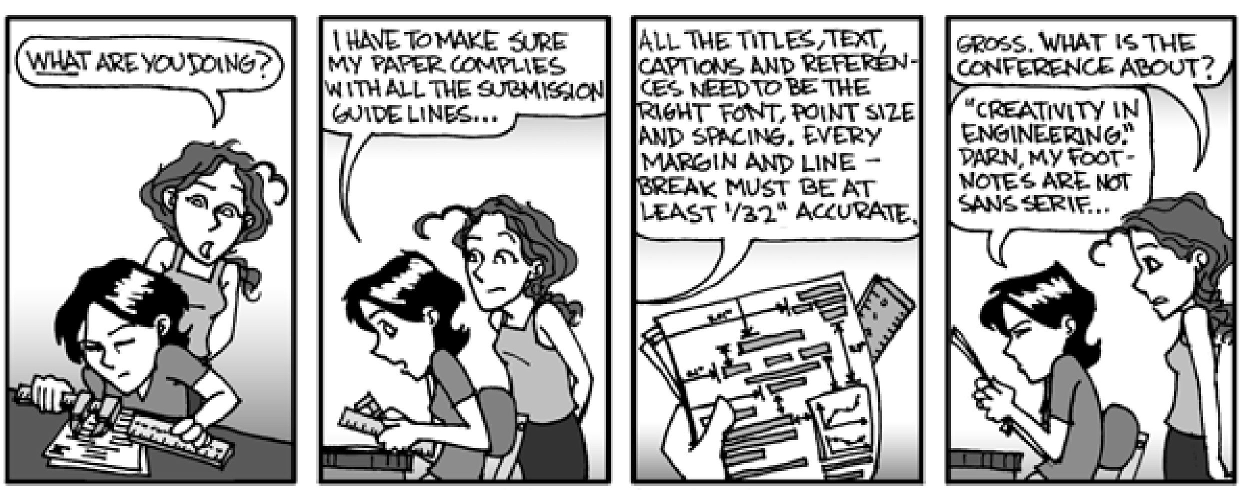

Figure 3: Creativity in Engineering ("Piled Higher and Deeper" by Jorge Cham /www.phdcomics.com)

explicitly want to highlight two sources that have already appeared to be useful to a large community: Firstly, the survival guide on paper writing by (Holst 2015), salted with worldly-wise glimpses behind the scene and peppered with sketches by Jorge Cham, the maker of PhDcomics.com. Secondly, the compilation of the reference style required by the American Psychological Association (APA), provided by (University of Queensland Library 2013). It provides a precise answer, including examples, to the question of how to cite virtually anything. For those curious and interested in more, we list a number of keywords, loosely arranged in the order of increased caution required when employed in class: DOI.org, IMRaD-Style, JabRef, Shape of Science, ResearchGate, PhDcomics, SciGen, SciHub.

It becomes clear from the above paragraph that we as teachers, while preparing the course, had naturally embarked on the course for ourselves which we claimed as a task for the faculty (as opposed to centralized institutions) in the introduction, namely to develop the emergence of scientific communication skills. We had become inspired enthusiastic learners, fuelling each other with new ideas, searching for more.

Agglomeration of research, learning and teaching

Eventually, we found ourselves doing research in teaching methods and scientific communication, resulting in a recursive learning – research – teaching experience. How did this work out for our students?

When working on the state-of-the art, several students openly expressed, what we had expected from browsing their thesis reference list: “Had I known this before …” When compiling a thesis, searching for similar work of others is only one feature of research, which may – in some cases – be skipped altogether due to time constraints and the many other new things to tackle (understanding of the problem, application of tools, writing the longest peace of text ever produced so far etc.). This still means the student can obtain a good result in solving the engineering project set out before her/him and why should she/he not repeat (i.e. research) the same thing for the hundredth time again in order to get some exercise? However, not being able to receive the impulses of others and to reflect one’s own results back to those findings strips the student of a vital skill in terms of communication with their peers. This was most openly revealed by one student who, after several iterations of looking for corresponding work in her field, wanted to give up: “I do not find anything”. This could only mean two things: She was still not in the position to apply appropriate criteria to her search or her thesis was a strong candidate for the Nobel Prize. We realized, therefore, that students do not naturally accept their role as researcher despite its closeness to being a learner.

The student’s role as a researcher surfaced again when we became aware that many students initially viewed the course as having little to do with their future job in industry. This can partly be blamed on the way we introduced the course, where we tried to tell how great it was to visit a real conference. This may have produced some frustration as students realized that most of them would probably never visit a real engineering conference. The question "Do I need research skills in working life?" (Murtonen *et al.* 2008) has to be addressed early in the course. This we will definitely change in our next run, conveying the message “you can do it” and trying to highlight how much enhanced communication is vital even for engineers. What we cannot immediately chance is the effect of a widespread exam- and content-focussed culture of learning, which is counteractive to the appreciation and positive experience of liminal space.

Application of active learning

From the beginning the students were pushed out into the open and exposed to active learning experiences such as group activity and, overall, to master their publication process as their own project. However, some sense of unease was noticed, whenever the results of a classroom session could not be measured in minutes spent for the consumption of information, i.e. when the students were responsible for producing their own learning outcome.

Not only the students had to grasp the changes in the learning process. Whenever free from transmitting information from the front, it was a privilege to watch students in the process of building skills to overcome barriers and to express oneself. The most prominent example of the development of self-authorship started with the confession of a student, who was reluctant to revisit her bachelor thesis. It appeared she had been at unease with the topic all along, being very glad that it was all over. We asked her about the topic and together, in a short discussion, we tried to arrange in our minds what she had been doing as her thesis. Weeks later, in a group exercise, she delivered the most precise outline of her thesis using a supportive sketch explaining it all. The breakthrough was at hand, howsoever it had happened.

Anticipation of liminal space and life-long learning

We had thus witnessed at various occasions that troublesome knowledge led to transformed thought and dialogue acted as a central element of transactional communication. This reassured us of our inspiration by the work of others, outlined in the introduction: Such "magic moments" are likely to occur by opening the liminal spaces, which small active learning elements can provide as well as exposure to a conference situation. As the students are near crossing their next threshold when entering working life, we hope to have served them to more readily accept the challenges ahead.

Additionally, we were able to share success (and failure) of our course development and implementation as we were operating as a teaching team. This helped us to increase the variety of challenges for achieving the same learning goals as well as to find different approaches to engage with the students. Not only because Engineering Conferences was our first genuine team teaching experience, we ourselves had entered liminal space and considerably stimulated our life-long learning adventure.

IV CONCLUSIONS & OUTLOOK

A master course module was designed, implemented, and tested with the goal to improve scientific communication skills of engineering students. As the name "Engineering Conferences" suggests, training is based around a mock-up conference, where students have to present the results of their bachelor thesis as a poster. The combination of the following features distinguishes the course concept from similar approaches:

1. It has a storyline (conference preparation) with a public finish (presentation day).
2. It engages the students as researchers, turning the publication of their thesis into a project.
3. It is mandatory for all master students of the faculty.
4. It is delivered by teachers/researchers from within the faculty,
   i.e. from "engineering native speakers".
5. It can easily be copied and integrated into any STEM curriculum.

For further development of the course, we still see ample room for extension of active learning methods. On a more structural and strategic level, this could lead to placing full responsibility for the organisation of the publication process into the hands of the students. This may require a change in the curriculum for a two-step approach for the student – first semester: participate only, second term: participate and facilitate.

In the future, the course could also serve as an active qualification and selection process for promotional activities of the faculty aiming at an increase in the number of research publications. To start with, we are working towards encouraging and sponsoring the best graduates of our course to participate in a real (undergraduate) engineering conference: The next liminal space waiting to be explored is only a doorstep away.

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Teaching Game Programming using Video Tutorials

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Keywords – Teaching, learning, programming, video tutorials.

ABSTRACT (POSTER)
Background. What are the learning potentials of using online video tutorials as educational tools in game programming of Mixed Reality? The paper reports on the first experiences of teaching third semester engineering students design of Mixed Reality using online step-by-step programming video tutorials. Mixed Reality covers in this case both Augmented and Virtual Reality. Until recently, most of the instructional support for the software and game development came from paper tutorials (van der Meij et al, 2016:332). YouTube's rapid growth in popularity and easy to use programs for video production makes video tutorials a promising alternative to paper tutorials. Software and game engine companies such as Unity has already switched to video and other online materials as the primary medium for their tutorials. It is often hard to find up to date thoroughly worked through textbooks on new and emerging topics such as Mixed Reality. Students tend to use video tutorial on their own initiative as supplementary tutorials for new and hard topics. This motivated me to use existing video tutorials as teaching materials in the course titled Mixed Reality for third semester engineering students.

Explanation. The learning approach was inspired by communities of practice and constructionist learning ideas (Lave & Wenger, 1991; Papert, 1993; Majgaard, 2014). The imitating and copying of step-by-step programming video tutorials was a part of becoming a member of virtual community around game programming. And in the classroom coding and experiences were discussed. The constructionist part was where the students revised and experimented by adding, combining and testing new coding elements to what they have already done in the tutorials.

Set-up. The students developed applications using the game engine Unity and tested the applications using android smartphones. The qualitative research method was based on design-based research, which support development of technological tools, curriculum and theory that can be used to understand and support learning (Barab & Squire, 2004; Majgaard, 2012). Empirical data were student made applications, tutorials, curriculum, observations and informal interviews.

Outcomes. Extending the applications based on the tutorials facilitated deeper learning for the students. For example, when they applied or recycled code components in new program contexts they developed a better and deeper understanding of the code. Surprisingly, comprehensive, polished and worked through tutorials promoted minor changes in the developed applications. Whereas, less polished and less professional tutorials made the students become more creative and diverse in development of extended application.

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Abstracts/Papers
Active Poster Session
Tuesday 14.50 - 16.10
Room 3.1.16
Theme: Teacher initiated learning

Time	Room 3.1.016 Theme: Teacher initiated Learning
Introduction 14:50-15:00	
Round 1 15:00-15:10	Acting active learning in large classes: Enhancing the learnings space with blended learning. *Lone Borgersen*
Round 2 15:15-15:25	Teacher's development and reflection in the flipped classroom. *Evangelia Triantafyllou, Olga Timcenko, Lise Busk Kofoed*
Round 3 15:30-15:40	Blended learning in embedded programming and microcontroller technique. *Ole Schultz*
Round 4 15:45-15:55	Flipping the classroom for a class on experimental vibration analysis. *Anders Brandt, Christopher Kjær*
Discussion 15:55-16:10	

ACTING
Active Learning in Large Classes: Enhancing the Learning Space with Blended Learning.

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Poster

ABSTRACT

Keywords – Active learning, Blended learning, scaffolding the learning process, differentiation, incentives

Background
"Active teaching and learning" is under pressure on the Faculty of Engineering, due to an increase in the enrollment of students and in the size of the classes. Both personally and interpersonally, things are very different in large classes. Students and teachers are not as visible as before, and for students it is much more difficult to get room for expressing themselves about professional matters. The purpose of the project is to investigate into the possibility for enabling active learning in large classes by enhancing the learning space with Blended Learning. The idea is to hand the possibility of being active in the learning space back to the students on existing courses on the first study year by adding net-based learning.

Explanation
Net-based learning has advantages concerning communication when compared to traditional teaching. (Illeris, 2007) notes that "It has been found that the fact that communication is written and delayed, involves some significant learning benefits. On one hand, through the personal contributions individual participants actually become more "visible" as persons for both the teachers and the other participants" and on the other hand " that social and interpersonal skills to a high degree are developed through written communication".

Set-up
During the spring 2016, I started to experiment with how to enable the students to become active learners in large classes by utilizing blended learning. In autumn 2016, I conducted a larger pilot, in which I have enhanced the learning space in an existing 1st semester course with about 130 students by introducing online dialogue as part of the module preparation. The intention was to get further experiences with blended learning, involvement of students, scaffolding the learning process, using the e-learning environment and motivational issues.

In 2017, I will further investigate into the possibility for enabling active learning in large classes by enhancing the learning space with Blended Learning. The objectives are to get knowledge about and to develop techniques for how to scaffold the learning process, to enable the students to communicate, connect and collaborate online, to differentiate online activities, to develop incentives for active participation, and to enable effective study habits and to involve the students in the planning.

Expected outcomes
So far, the pilot implementations show several possible enhancements of the learning concerning student preparation, learning outcome, and engagement in the subject area. The data from the pilot will be analyzed by SDU Universitetspædagogik, and so will the data from the development project.

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Teachers' development and reflection in the flipped classroom

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ABSTRACT

Keywords - Flipped Classroom, Teacher Development, Teacher Cycle, Mathematics.

Please indicate clearly the type of contribution you are submitting: ___ hands-on, ___explore, _x_poster.

The flipped classroom is an instruction method that has gained momentum during the last years due to technological advances allowing the online sharing of teaching material and learning activities. Bishop and Verleger defined the flipped classroom as "…an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom" (Bishop & Verleger, 2013). So far, research on flipped classroom has mostly concentrated on student perceptions, engagement and achievement level, e.g. (Enfield, 2013; Fulton, 2012). Few studies have focused on teacher perceptions and development in flipped classrooms, e.g. (Hao & Lee, 2016; Wanner & Palmer, 2015). This poster presents findings on teacher development during a three-year implementation of a statistics flipped classroom in Media Technology. Our experience has shown that teachers reflected on their own teaching even before the event of teaching, because the design of a flipped classroom requires careful consideration of the course structure and content. In many cases, the teachers had to come up with new activities or redesign the whole course in order to adjust it to the flipped classroom model. We have also seen that these considerations have forced teachers to also reconsider the learning objectives of specific activities. Another aspect that promoted reflection was the production of video lectures. Finally, teachers reflected on each flipped session (out-of-class, in-class) and they adjusted the next one throughout the semester, and after the end of the semester they reflected on this experience as a whole. These reflections promoted the redesign of their flipped classroom approach for the next year. The aforementioned considerations led us to conclude that the flipped classroom approach can convert teaching experience to professional development by involving teachers in reflection loops. In order to better visualize such loops, we adjusted the Teaching Cycle of the Learning Design framework (Dalziel, 2013) to fit Cowan's reflection loops model (Cowan, 1998).

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Blended learning in embedded programming and microcontroller technique

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ABSTRACT
Blended learning, e-learning, video, survey, simulation

Active poster session

Background
The course has run for 1½ years, this semester being the fourth time. Observations from previous semesters had been that I spent 2 – 2½ hours in the lecture hall presenting material by using slide series and at the end demo programming. Before the students hand-on, I "live programmed" using the Atmel Studio IDE in front of the students, as Michael Caspersen et al. Lit 1 proposes. They were engaged to follow what I did. Last semester, I even recorded the screen and talk. Some students said in the evaluations that they would like more hands-on. I participated in the Learning labs course about blended learning and became inspired.
Therefore, I posed myself the question "**Is it possible to compress a 1 hour talk with slides to a 5 to 10 minute video and to let the students be more active during the programming exercises in the 4 hour lecture slot?**

The presentation will show and discuss how students get more time for programming exercises in the 4 hour course as well as the tools used. An evaluation of the findings so far will be given. The digital electronics and programming course is a 5 ECTS course given on the 2nd semester of the B.Eng in Electrical Engineering degree course. A teaching experiment was performed fall-2016 during 13 weeks. At the conference I will describe and discuss the results in relation to previous teaching methods used during the last 3 occasions the course was offered. Together with video, some test questions are provided in a quiz or as multiple choice questions which should be taken after seeing the video.

I use PowerPoint slides and a screen recorder from Camtasia where it's possible to record with the camera on the lap top or an external one. Along with the slide a video of the presenter's face is shown, lit2. The duration is kept below 10 minutes – (lit. 2) recommends 6 minutes. The recoding is done in an informal setting. lit. 2 suggests: "instructors speaking fairly fast and with high enthusiasm are more engaging"(lit2).

Thus the focus of learning shifts from teacher centered to active learners. Learn everywhere.
The active learning is practiced by team work with 2-3 students completing a total of 5 deliverable assignments together.

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Experiences with flipped classroom teaching in a vibration analysis class

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ABSTRACT

Keywords – flipped classroom, experimental vibration analysis, lecture videos

Type of contribution: poster.

Flipped classroom is a relatively new teaching form, aimed at improving the learning process by allowing more active discussions between lecturer and student (Este et al. 2014, Hachmann & Holmboe 2014). The concept is that the students study the course stuff prior to class, for example by watching videos of lectures, or by working through a text. The classes are then focused more on assignments and discussions targeting higher cognitive functions. This can make better use of the teacher's competence, as the focus can be on the more difficult things in the course content, while also aiding the students better. The definition of flipped classroom teaching that we subscribe to can be defined as "… that students gain first exposure to new material outside of class, usually via reading or lecture videos, and then use class time to do the harder work of assimilating that knowledge, perhaps through problem-solving, discussion or debates" (Brame 2015).

In the present paper, we discuss some recent experiences of using the flipped classroom technique for a course on experimental vibration analysis. First, using Bloom's revised taxonomy (Andersen & Krathwohl 2001) which learning goals can be characterized as lower levels of cognitive work which students can work with outside of class and which learning goals can be characterized as the higher forms of cognitive work where the students' needs to have support in class by the more experienced teacher were defined. Videos presenting the main theory for each lecture were then recorded and published on YouTube (Brandt 2017), and exercises for student preparation before each lecture were developed. Next, multiple-choice questions for using clickers, and questions for discussion during the lectures, were developed. The experiences so far are that the teaching technique is relatively time consuming to implement, but that the students appreciate being able to work with the course stuff at their own pace while preparing for the class. Also, it turned out that the way the videos were used was very different among different students.

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Abstracts/Papers
Hands-on Session 3
Wednesday 10.20 - 11.50

	Hands-on 1 Room 3.0.02	Hands-on 2 Room 3.1.16	Hands-on 3 Room 3.1.15	Hands-on 4 Room 2.0.08
	Technology as Panacea!? Improvised Skits to Solve a Common Problem Across the Centuries	Admission Tickets	Innovation Pilot – To improve innovation competencies of Engineering students	Sustainability in Danish Engineering Education
Author(s)	André Baier	Jacob Arnbjerg	Hanne Løje Sara Grex	Ulrik Jørgensen
Chair	Aage B. Lauritsen	Mona-Lisa Dahms	Regner B. Hessellund	Author

Technology as Panacea!?
Improvised Skits that Tackle Water Contamination Across the Centuries.

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Extended Abstract for a Hands-on-Session

Keywords - technological fixes, history of technology, ethics of technology, theater play, power relations, society-nature relations

Abstract

There is a strong demand for technological innovations as a remedy for ecological destruction and as pathway to poverty eradication. The predominant belief in technological progress is held up through technicians as well as a society wishing for easy technological solutions for complex ecological and social problems (Pongratz and Baier 2015). Taking this into account, this paper outlines the Blue Engineering Course design that promotes socially and ecologically responsible engineering through the use of building blocks, i.e. self-contained study elements. One of the core building blocks addresses the development of water supply and how societies have dealt with this issue over the course of human history. Participants of this building block improvise skits how they would deal with a sudden water pollution with yet an unidentified cause in six different centuries. This helps to facilitate a discussion about society-nature relations as well as power relations.

I Blue Engineering Course at Technische Universität Berlin

This course is the result of a student-driven initiative at Technische Universität Berlin that formed in 2009 (Baier 2013). The very idea that a group of students engages in the creation of a meaningful course not only underlines the shift from teaching to learning, but it shows how seriously this shift can be done. Over the course of four semesters, this student group has developed a course design that disregards any teacher-centered form of education. Instead they have enforced a student-centered approach, so that engineering students acquire the competences to unveil the complex interdependency of their social, political, ecological and economic surroundings. This thorough analysis helps to grasp the personal responsibility as well as the collective responsibility as engineers and humans on micro and macro level (Baier and Pongratz 2013). For the students will also learn to consider the different values, interests and needs within a global perspective as well as within one class(room). The course design encourages democratic decision-making and the corresponding action not only to solve but also to define problems within the course itself and moreover outside of the classroom (Pongratz and Baier 2015).

The first Blue Engineering Course has been conducted by four student-tutors in the winter-semester of 2011/2012 with 25 participants. From the very start it was a course which could be chosen from a list of few possible courses where a certain number of courses from this is compulsory for the master programme of mechanical engineering. This selection of a specific number ‘compulsory’ courses is a widely practiced at German Universities. Therefore the Blue Engineering was credited with 6 ECTS points from the very beginning. The evaluation and the feedback was overwhelmingly positive so that the student-group offered their course in the next semester as well. This rendered equally positive feedback. Starting from winter-semester 2012/2013 the student-group was granted one lecturer position and two tutor positions in order to ensure a successful further conduction and development of the course.

By now, the course has been conducted 12 times and attracts on average 90 students. 35% of the participants study mechanical engineering and another 35% study industrial engineering where it has been an option of compulsory electives since 2014. The remaining 30% of the participants chose the course as an elective.

Generally speaking, the 14 weeks of a semester are divided into three parts. In the first, tutors conduct a fixed set of building blocks in order to give the participants a concrete idea of what is expected of them later on. In the second part, groups of three to five students conduct already existing building blocks for their fellow students of the course. For this they can choose from list of over 150. In the third part, the students groups conduct a building block which they have developed over the course of the whole semester. The student groups receive continually feedback as well as formative assessment in order to ensure a high quality of the newly developed building blocks.

Building blocks, i.e., self-contained study-elements, are at the core of the Blue Engineering course. They provide clear didactical instructions to facilitate a 60-90 minutes workshop as well as compact, yet multiple perspectives on a complex topic, e.g., ethical codes, recycling, pre-implantation diagnostics, social businesses, gender&diversity, rebound-effect, fracking or cooperatives. Some of these study elements help to thoroughly analyse single technologies while others address social structures and how to change them. Along with the wide variety of topics, every single building block uses a specific set of teaching formats such as case studies, story-telling and station learning. Most building-blocks, however, rely on a specific adaption and new combination of known methods, e.g. learning cascades, advocatus diaboli, triangular method, evaluation sculpture, crime scene investigations and court trials, educational games and challenges. In total, there are now over 150 building blocks (Blue Engineering 2017).

The conduction of an existing building block as well as the conduction and documentation of the newly developed building block are part of the summative assessment. In addition, the students individually keep a learning journal over the whole semester.

The evaluation is presently prepared to be published. For this evaluation, competences that are linked to an education for sustainable development (Haan 2006; 2010) have been adapted as learning outcomes to the specific setting and requirements of the course. They are further designed-down to be used on module level as well as on lesson level (Baier and Meyer 2016). Based on these learning outcomes, a quantitative self-evaluation form has been developed. This self-evaluation of the students takes place at the beginning and at the end of each semester. The results show, that the students perceive themselves as significantly more competent at the end of course in all tested areas. In addition, there is a qualitative analysis of learning journals taking place that students keep over the course of the semester.

Besides the Blue Engineering Courses at Technische Universität Berlin, there is one course at Technische Universität Hamburg-Harburg since 2012 and one at Hochschule Düsseldorf since summer semester 2016. They are fully conducted by students and student-tutors which even more underlines the student-driven and student-centered approach of the Blue Engineering initiative.

II Building Block "Technology as Panacea!?"

The participants of this hands-on session will participate in a building block that presents how (wo)men have dealt with a sudden pollution of drinking water in different ages of mankind. The building block is called "Technology as Panacea?!" and is a core building block that is conducted each semester. It has been conducted now over 30 times within the course as well as at various (international) workshops to discuss the historic development of technology and its impact on nature and society.

The participants are divided into six groups and each must solve the same problem of sudden drinking water contamination but in another human age, i.e. Stone Age, Roman Empire (Lang and Svenshon 2015) (Schneider 2015), Middle Ages, Industrialization (Wieland 2015) , Present (Dinçkal 2015) and Future. The groups must then depict their solutions through small skits. After each skit there is a short discussion and at the end there is a concluding discussion that aims at pointing out the commonalities and differences between the centuries.

This building block helps to realise that technology increasingly becomes a future cause for possible contaminations of water and nature while creating congruent solutions. Thus, the participants realise how society is shaping technology and how technology is shaped through society in return. This includes notably the spatial and temporal effects of technology. In addition, the participants realize that contamination of water is not something that has happened a long time ago or that will happen in the far future, but that it is happening today even within western states (Carson 2002). Overall, this leads to a deep discussion about society-nature relations (Swyngedouw 2004) and power relations (Swyngedouw, Kaika, and Castro 2002) with respect to water but also within our present society in general (Engels and Schenk 2015). People generally are very touched by the building block for through the theater-play they gain more insights as this is a non-traditional form of learning.

Points for the concluding discussion are:

- What are possible causes for the water pollution? In the Stone Age it's mostly natural, biological, geographical causes, (wo)men have little influence - this increases constantly over the ages - technology will eventually become a major cause
- What role did the causes play in the presentation? The participants usually focus on the solutions - totally neglecting the causes

- Water as a most basic need of (wo)men - Participants often don’t realize/show in their presentations that water is necessary not only for human life, but for all life
- How is water distributed? Who controls the access to water? - Commodification of water in the present, access to water as a "weak" human right, water as a common good
- How to decide water issues? Water and power relations, water and democracy
- Who is affected by the water pollution? In Stone Age the whole nomadic group, in the Middle Ages and Present Age people are differently affected, since certain people have the resources to find their individual solution
- Advancing centralisation of water pumps - there are three central spots for the water supply of Berlin
- Have social solutions been considered? Many times they are totally ignored.
- What are the common points of the found solutions in all ages? Mechanical Filtration, Cooking, Biological/Chemical Treatment, Import of Water, Exodus to another area (in the future scenario even leaving to another planet)...
- What are actual water pollutions which happened in the last decades? Is it a problem elsewhere/outside of Europe? No, pesticides, aluminum production, nuclear power plants, hormones, antidepressants, pain killers

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Admission Tickets

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ABSTRACT

Keywords – Student activity, mandatory preparation, student motivation, teaching as a right or a privilege

Please indicate clearly the type of contribution you are submitting: **X hands-on**, ___explore, ____poster.

Most teachers will know the familiar problem that they feel students do not come prepared for the teaching activities. This may have a number of unwanted and negative consequences, including

i) frustration for the teacher as well as those students who have come well-prepared
ii) confusion for the teacher in terms of selecting the appropriate material and the academic level
iii) being part of establishing a negative culture around "that it is ok to come unprepared"

The concept of using admission tickets is aimed at addressing the abovementioned challenges. Simply stated, the teacher establishes conditions such that it is not "free-of-charge" to attend the teaching activities. And before the students can gain access to the teaching session, they must demonstrate they have access rights. This may be in the form of handing in exercises done in advance or other mandatory out-of-class activities. If the students have not prepared they are in principle not granted access to the teaching session.

This is clearly a somewhat provocative approach, as it touches upon some very fundamental questions about teaching and the students relations hereto. Is teaching a right, a duty or a privilege? Experience shows that the concept of admission tickets can indeed be very effective and help student motivation and active participation. But it is critical that the concept is presented in the right framework and that it becomes a matter of mutual trust rather than mistrust. As such, a serious amount of preparation must be done in advance, both in terms of how to present the concept to the students, but also in terms of the concrete activities intended. Activities should be properly aligned with the intended learning outcomes such that the students can see a clear benefit.[1]

Experiences will be shared from personal experiences from a course where the concept was implemented successfully. Here the admission ticket was in the form of completing exercises which addressed topics from the previous teaching session. This way the students automatically got to repeat key points, which helped them link previously encountered concepts with the current topics.[2] Student responded positively when asked if the "teaching activity had helped them in their learning" (87 % strongly agreed), and also if "the level of feedback during the course was good" (67 % strongly agreed). This was reflected by the students "delivering high academic effort" (93% strongly agreed) and also by a very high grade average at the final oral exam (9,1 in average in a class of approximately 60 students).

Following a brief introduction, the participants will work with how this conceptual framework might be implemented in their own work and what benefits and possible challenges they may foresee. The session will be concluded with a discussion and evaluation in plenum.

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INNOVATION PILOT – TO IMPROVE INNOVATION COMPETENCES OF ENGINEERING STUDENTS

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ABSTRACT

Keywords - innovation, multidisciplinary, company case, double diamond process model

Please indicate clearly the type of contribution you are submitting: _X__ hands-on, ___explore, ____poster.

Background and explanation

In autumn 2016 a new mandatory course *Innovation Pilot* was running for the first time. The course is a result of introducing an updated diploma program at the Technical university of Denmark (DTU) and the new activity in the program is a new common 10 ECTS compulsory course in innovation and multidisciplinary (Nyborg and Christiansen, 2016) called innovation pilot with the focus on enhancing the innovation competences of the bachelor engineering students.

The innovation pilot course is placed on the 5th or 6th Semester of the education after the students have fulfilled the compulsory part of the education (Nyborg and Christiansen, 2016). The innovation pilot course is offered three times per year in the two semesters (13 weeks) and as intensive summer course (6 weeks) from summer 2017. At DTU there are 17 study programmes involved and it is expected that approximately 450 students will attend the course during each spring and winter semesters.

The outline for the course is that the students work in multidisciplinary teams with specific challenges offered by companies and the idea behind the course is that the students are trained to act as pilots for innovation projects in collaboration with companies. The companies provide open-ended projects which take a starting point in actual challenges observed by the company.

The main scope for this session is a discussion of how to enhance innovation skills/competences in large mandatory course with heavy company involvement and students from many different study programmes?

The process, i.e. the methods used and/or approach taken

Double Diamond is a process model created by Design Council, a British organization, in 2005 (Design Council, 2005). The model provides a graphic representation of a design process. The double diamond model presents four main stages across two adjacent diamonds. The first diamond in the Double Diamond model concerns problematisation and understanding of a problem. The second diamond is the problem solving phase. Each of the four stages is characterised by either divergent or convergent thinking. These stages are:

Stage 1 - Discover –identify, research and understand the initial problem.
Stage 2 - Define – limit and define a clear problem to be solved.
Stage 3 - Develop – focus on and develop a solution.

Stage 4 - Deliver – test and evaluate, made the concept ready for production and launch.

At the course innovation pilot, the Double Diamond model is used to support the innovation process. During the semester course the students will go through three loops and in each loop the students will conduct an innovation process structured according to the double diamond model.

The company is the problem owner and the students should involve the reality of the company in solving the challenges.

During the work with the double diamond model the students are describing the context of the company problem. Furthermore they will develop prototypes and make suggestions to company for how to proceed further, all which are documented in a report. Furthermore the solution should make sense for the company seen from a business, organizational, operational and technological perspective.

Set-up (activities and materials, assessment, evaluation)
During the hands on session the participants will be dividing into smaller groups and discuss pros and cons using the double diamond process model for structuring an innovation process. After some time new groups will be made and new discussions will take place which also will include the aspect of using other models to improve the innovation competences of engineering students based on the participants own experiences.

Expected outcomes/results (possibly data/experience from own practice).
The expected outcomes are more experience which the authors can use for further improvement of the process model in the course.

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Exploring the challenge of bringing sustainability into engineering

Introduction by: Ulrik Jørgensen
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ABSTRACT

Keywords – sustainability, curriculum, institutions, frames, episteme, engineering.

Introduction to the hands-on session

Sustainability is on the agenda in most engineering institutions and programs – it is so to say a contemporary, unavoidable issue. A study of implementation strategies and practices is the background for setting the stage for a contemporary discussion of the challenges that sustainability presents to the politics of engineering institutions, to the profession and to engineering education. The study is presented in a recent book on Engineering Professionalism from which the chapter is taken, and a seminar where contemporary experiences from a number of Danish engineering institutions were discussed.

The main challenges are identified, different approaches discussed and the need for an operational set of metrics as well as a rethinking of engineering is presented.

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Abstracts/Papers
Explore Session 3
Wednesday 10.20 - 11.50

	Explore ”Yellow Room”
	1: From Vision to Action: CDIO-reform for engineering programs at Blekinge Institute of Technology 2: Design Thinking – teaching the Engineering Skills of the 4th Industrial Revolution 3: Impact of a Social and Behavioural Sciences of Learning Course for Engineering Students
Author(s)	1: Ulrica Skagert & Anton Borg 2: Kirsten From 3: Roland Tormey
Chair	Pernille H. Andersson

From Vision to Action: CDIO-reform for engineering programs at Blekinge Institute of Technology

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ABSTRACT
Keywords – CDIO, educational reform, engineering, combined approach

Type of contribution: explore session

In this session we would like to present and discuss how on a program-cluster level we at BTH have worked with a CDIO approach (Crawley *et al.* 2014) to develop the engineering programs that better educate engineers who "are ready to engineer." At a highly profiled institute with civil engineering programs and an aim to convert Bachelor of Science into Bachelor of Science in Engineering. We have the intention to reform all our programs to better meet the requirements from industry and society in terms of graduating students who are better prepared to meet the challenges at a workplace and its context. We believe that reform work and development of a cluster of programs simultaneously will give us benefits like:

- Cooperation effects
- Coordination effects
- A common ground for what engineering means
- Possibilities to share good practice across subject and department borders

We have come to believe that these benefits in turn and taken together lead to higher-quality programs (Cardenas *et al.* 2013).

Through a number of activities we have worked with a selection of the standards that constitute the CDIO-approach trying to combine them in order to be efficient. These are:

Standard 3. (Towards an) **Integrated curriculum**

Standard 4. **Introduction to Engineering**

Standard 7. **Integrated learning experiences**

Standard 8. **Active Learning**

Standard 10. **Enhancement of faculty teaching competence**

Standard 12. **Program evaluation**

Our aim during this session is to explore our experiences with the work-in-progress of converting a Bachelor program and adapting it to CDIO, focusing on standards 8 and 10. And, we wish to discuss benefits, obstacles and difficulties that we have come across as well as future possibilities with our approach.

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Design Thinking – teaching the Engineering Skills of the 4th Industrial Revolution

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Keywords – Design Thinking, 4th Industrial Revolution, thinking skills, cognitive flexibility, creativity

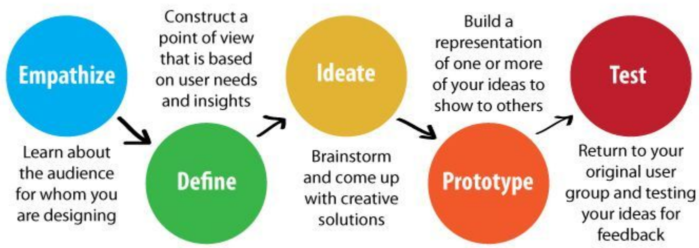
Please indicate clearly the type of contribution you are submitting: **Explore**

ABSTRACT
Background: According to the World Economic Forum (WEF) (https://www.weforum.org/) we are now facing the 4th Industrial Revolution. New technology will change the world in many ways that we can't see the full extent of at this point. Two thirds of the jobs of the future don't even exist yet. How do we prepare our students for that future when we don't know what those jobs are?
WEF has made a list of the top 10 skills of the future (http://bit.ly/1qyDkb6):

1. Complex Problem Solving
2. Critical Thinking
3. Creativity
4. People Management
5. Coordinating with others
6. Emotional intelligence
7. Judgment and decision making
8. Service Orientation
9. Negotiation
10. Cognitive Flexibility

I believe that students can train most or all of these skills through participation in Design Thinking projects. I am preparing to do a research project which aims to document this. For now I would like to focus on Cognitive Flexibility which is a core component of creativity (Ritter *et al* p 961).

Explanation: Design Thinking (DT) is a Human-Centered Innovation approach which is taught in The Hasso Plattner Institute of Design (D:School) at Stanford University (http://dschool.stanford.edu).
The DT process has a number of phases and activities which requires participants to be able to shift quickly between different modes of thinking. I would argue that this requires Cognitive Flexibility because these modes are so different in character and entails everything from empathetic listening to analysis/synthesis. Another type of shift required from the students is a "Mindshift". A Mindshift is a "re-synthesis and reorientation of their worldviews" (Goldman *et al*, 2012). Four different Mindshifts have been identified in DT: "Human Centrered", "Collaborative", "Metacognition", and "Experimental". (Goldman *et al* 2012). I would argue that Cognitive Flexibility plays an important role there too. In my presentation I will further expand on my view of Design Thinking and the benefits of using this approach in Engineering Education.



Set-up: I'm planning an Action Research project for the Autumn (2017) and next Spring (2018) aiming to gain a more precise understanding about which skills students learn during DT projects.

Expected outcomes: I expect to gain a much deeper knowledge about what the students learn, and how DT can provide Engineering students with the skills they need for the 4th Industrial Revolution.

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http://dschool.stanford.edu

The impact of a course on social and behavioral sciences of learning on science and engineering students

Presenter: Roland Tormey[1]

Explore session paper proposal

Metacognition (or 'thinking about thinking') has been identified as an important element of the education of professional engineers and scientists for a number of reasons. First, metacognition is an integral part of the process of problem solving [1], and problem solving is at the heart of the engineer's profession [2]. Second, metacognition is linked to learning; people who are more metacognitive and conscientious in their approaches to learning tend to perform better on assessments [3]–[5]. Finally, metacognition is closely associated with the ability to take what is learned in university and to apply it in real life settings (called 'transfer' in the psychological literature)[6].

Since 2012, EPFL Master students have had the option of taking a course in social and behavioral sciences of learning as part of the Social and Human Sciences strand within their studies. The 6 ECTS credit course provides students with an opportunity to participate in a series of lectures and workshops/experiments on learning. Thereafter, students complete a group research project in which they investigate an aspect of teaching or learning of engineering or science. This student research is then presented to the EPFL community at both a poster event and at the annual faculty retreat. The idea is to create a virtuous learning cycle where students learn how to undertake social research by undertaking realistic projects which in turn provide useful data to teachers and to the wider school community.

In 2016-17 the students were asked to provide qualitative feedback on the course, and their learning from it. This paper presents a brief summary of the results of some of the student research projects, as well as data from the qualitative study of the course impacts.

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