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Active Learning in Sustainability Teaching

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Exploring Teaching for Active Learning in Engineering Education
DTU, Copenhagen, Denmark
November 11-12 2015

Book of Abstracts

DTU Skylab
– where it begins

DTU Technical University of Denmark

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Aarhus University School of Engineering

Exploring Teaching for Active Learning in Engineering Education DTU, Copenhagen, Denmark November 11-12 2015

Day 1	November 11	
09.00-10.00	***Registration - coffee and tea***	
10.00-10.10	Welcome	
10.10-10.55	**Active Keynote** Gillian Saunders-Smits	**"Engineering Engineering Education"**
11.15-12.45	Parallel Hands-on/ Explore sessions	
12.45-13.30	*Lunch*	Scion DTU
13.30-15.00	Parallel Hands-on/ Explore sessions	
15.00-15.30	*Coffee and tea*	
15.30-17.00	**Active Poster session**	
17.15-18.15	**Mind tickling** Peter Vuust	"Imitate, Assimilate, Innovate and Practise - Active music learning and the brain"
18.30-19.00	*Beer brewing and tasting*	With Jazz music
19.00-21.15	*Conference Dinner*	With Jazz music
Day 2	**November 12**	
09.00-10.00	Active Keynote Morten Friis-Olivarius	"The Brain, creativity and learning"
10.00-10.20	Coffee	
10.20-11.50	Parallel Hands-on/ Explore sessions	
11.50-12.00	Thank you and good bye	See you again?!
12.00	*Lunch*	Sandwich To Go

Keynotes

Keynote - "Engineering Engineering Education"

Dr. Gillian Saunders-Smits

Dr. Gillian Saunders-Smits has a Master Degree in Aerospace Engineering from Delft University of Technology, Faculty of Aerospace Engineering in the Netherlands and a Phd in Aerospace Engineering Education from the same institute.

She has been teaching aerospace engineering for more than 15 years.
She currently serves as the Master

Track Coordinator at the Aerospace Structures & Materials department and teaches first year Mechanics and Research Methodologies in the Master as part of the Aerospace Structures and Computational Mechanics group. She is also the Faculty's online education coordinator.

She has a real passion for quality engineering education and firmly believes that engineering education like engineering design is never finished and that we should always continue to look for the optimum. Her research interest include engineering education, project and problem based learning and online education.

Keynote - ”Imitate, Assimilate, Innovate and Practise - Active music learning and the brain”

Peter Vuust

How do we learn to be innovative? That is a question most musicians ask themselves every day. Based on the newest knowledge about the brain, bass player, composer and neuroscientist, leader of DNRF's Center for Music In the Brain - Peter Vuust - talks about

How we become better at creating
What happens in the brain when we learn something new
Musical development in the brain.

Professor Peter Vuust, Ph.D. holds joint appointments at the Danish Royal Academy of Music and the Center for Functionally Integrative Neuroscience, Aarhus University Hospital where he is the Leader of the new Danish National Research Foundation's center for "Music In the Brain". He obtained his doctoral degree from the Medical Faculty of Aarhus University, in addition to his various M.Sc. in mathematics, French and music. He has published highly cited articles on music in the brain, using state-of-the-art brain scanning techniques such as fMRI, PET, EEG, MEG and behavioural measures and has written a monograph "Polyrythm and –meter in modern jazz; a study of Miles Davis' Quintet from the 1960s”. In addition, Prof Vuust is a jazz bassist and composer; leading the Peter Vuust Quartet with Alex Riel, Lars Jansson and Ove Ingemarsson of which six records have been released so far. He has also played on more than 85 recordings and been sideman with international jazz stars such as Tim Hagans, John Abercrombie, Dave Liebman and many more. He is the recipient of the 2009 Jazz Society of Aarhus' "Gaffel"-prize. His latest album “September Song” has been widely acclaimed by reviewers and received a nomination for a Danish Music Award in 2014.

Keynote - "The Brain, creativity and learning"

Morten Friis-Olivarius

Creativity lies at the core of all human behavior – in teaching, research, invention, innovation, entrepreneurship, management and leadership and so forth. Yet, there is a common belief that only certain people possess some mystical, creative thought process that places them above all others in their unique skills for having creative and groundbreaking thought. Naturally, this is nothing but a myth. By understanding what creativity is, and learning how to identify and manipulate various creativity constraints – both practical and mental (neurological constraints) – anyone can learn how to utilize their personal skills and competencies creatively.

In this Keynote, Morten will guide us through the neuroscience of creativity and explore the causal neural mechanisms that enables creative behaviour, why some are more creative, and how to enhance creativity in engineering education.
Morten has a PhD in the neuroscience of creativity and is a creativity researcher at the Center for Decision Neuroscience, Copenhagen Business School (CBS) and the founder of the Copenhagen Institute of NeuroCreativity – an institute devoted to understand and disseminate knowledge about the neurological underpinnings of creativity and creativity training.

Morten has a PhD in the neuroscience of creativity and is a creativity researcher at the Center for Decision Neuroscience, Copenhagen Business School (CBS) and the founder of the Copenhagen Institute of NeuroCreativity – an institute devoted to understand and disseminate knowledge about the neurological underpinnings of creativity and creativity training.

ETALEE 2015 Sessions

Active session 1
Wednesday 11.15-12.45

	Hands-on 1 Skylab Auditorium	Hands-on 2 Apollo	Hands-on 3 Basement	Hands-on 4 Skybox	Explore Scion Auditorium
	Designing Engineering Education the Engineering Way	Take the laboratory into the classroom	Want to try out Problem-based learning?	Method for construc-ting test questions of a new innovative item format	"Student competencies - Sustainability" 1: Active Learning in Sustainability Teaching 2: Teaching relational understandings of sustainability in engineering education
Author(s)	Gillian Saunders-Smits	Claus Melvad	Tina Elisabeth Nielsen, Sabine Schmidt	Meta Keijzer - de Ruijter, Celine Goedee	1:Alexis Laurent, Stig I. Olsen, Peter Fantke , Pernille H. Andersson 2:Erik Hagelskær Lauridsen, Ulrik Jørgensen
Chair	Jørgen B. Røn	Aage B. Lauridsen	Claus M Spliid	Regner B. Hessellund	Mona-Lisa Dahms

Active session 2
Wednesday 13.30-15.00

	Hands-on 1 Skylab Auditorium	Hands-on 2 Skybox	Hands-on 3 Basement	Hands-on 4 Apollo	Explore Scion Auditorium
	Design Thinking as a tool for the design of Engineering Education	The flipped classroom: design considerations and Moodle	When a "good" problem is key to success... Design a problem for PBL?	Self-education - learning by sharing and doing	"Student competencies - Scientific Thinking" 1: Learning how to apply complex abstract models in the biomedical domain by stepwise reflection. 2: Detective work: Supporting engineering students' learning when reading scientific texts.
Author(s)	Renate Klaassen, Alexia Luising	Evangelia Triantafyllou	Sabine Schmidt, Tina Elisabeth Nielsen	Christian Perti	1: Anne Randorff Højen, Kirstine Rosenbeck Gøeg 2: Kirstine Rosenbeck Gøeg, Lone Krogh
Chair	Pernille H. Andersson	Jørgen B. Røn	Aage B. Lauridsen	Regner B. Hessellund	Mona-Lisa Dahms

Active session 3
Thursday 10.20-11.50

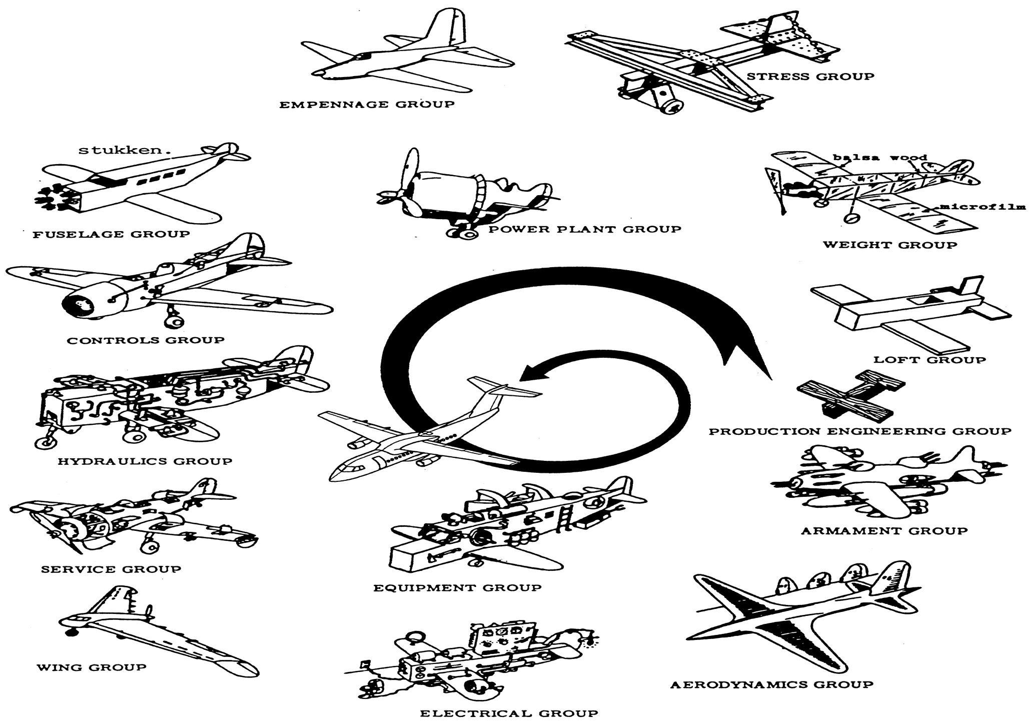
	Hands-on 1 Skylab Auditorium	Hands-on 2 Apollo	Hands-on 3 Basement	Hands-on 4 Skybox
	The Study Activity Model SAM - Enhancing Active Learning?	Teaching Engineers Innovation Competencies	Supplemental Instruction (SI) Collaborative peer learning	"Student competencies - Innovation" Help to recruit the future Engineers – And learn how to activate learners through Design Thinking
Author(s)	Mona-Lisa Dahms, Claus Monrad Spliid	Nynne Budtz Christiansen, Mai-Mai Ulrich	Leif Bryngfors	Maja Lund Pontoppidan
Chair	Regner B. Hessellund	Jørgen B. Røn	Aage B. Lauridsen	Pernille H. Andersson

Abstracts/Papers
Hands-on Sessions

Workshop Designing Engineering Education the Engineering Way

Dr. ir. Gillian Saunders-Smits
Delft University of Technology

"A completed airplane is in many ways a compromise of the knowledge, experience and desires of the many engineers that make up the various design and production groups of an airplane company" – C.W. Miller



Dream Airplanes by C.W. Miller

In this hands-on practical workshop we will show you that the same can be said for curriculum design of engineering education. In this workshop you will have the opportunity to design a course, a module or maybe even a semester using the principles of engineering design. Participants are encouraged to bring in their own case so that they may walk away with an outline of a new course and be inspired to develop it further and connect with other lecturers going through the same process in order to learn from each other.

In small pairs or small groups you will go through the steps of engineering design but this time applied to engineering education:

- identifying relevant design requirements both internal (learning objectives) and external (cultural and educational framework) – 10 min
- requirements review - 10 min
- conceptual design phase in which different version of the same course are developed using different teaching & assessment methods in each (i.e. project based, traditional lecture, blended, etc.) – 30 min
- design review in which each idea is pitched against each other highlighting advantages – 10 min
- trade – off and selection of final design for further development – 10 min

References

Saunders-Smits, G.N. (2014), Design of an MSc Degree course in Aerospace Structures & Materials, SEFI 2014, Proceedings of the 42nd Annual Conference, Birmingham, UK.

Crawley, E., Malmqvist, J., Östlund, S., Brodeur, D. (2007), Rethinking Engineering Education – the CDIO approach, Springer, New York.

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Laurillard, Diana (2012), Teaching as a Design Science - Building Pedagogical Patterns for Learning and Technology, Routledge, London.

Take the laboratory into the classroom

Claus Melvad
Aarhus University School of Engineering
Denmark
cme@ase.au.dk

ABSTRACT
Hands-on, Miniature systems teaching, Large classes

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

It is a wonderful thing when students forget about time when trying to get a setup to work. Working towards such a concrete goal they will get immediate feedback from the system itself, by whether it is working as intended or not and they need to analyse and understand the setup to solve open issues which engages the students (raft.net, 2013).

The number of students for engineering education is increasing in Denmark (ufm.dk, 2015), and often laboratory space cannot keep up. Considering adult leaning processes (Kolb, 1984) and the preferred learning style for each learning stage (Honey and Mumford, 1982) the active experimentation forming the concrete experience are part of the learning process best learned when trying things out to see if they work. So sacrificing experimentation due to an increasing amount of students is inefficient without reducing the expected learning outcome. In this work a different solution is sought.

One way of solving the issue could be to split the big classes into small teams and then each team gets a certain amount of lab time together with the educator. However this is very time intensive and teaching is at the risk of becoming an uninspiring record player, playing the same song over and over again. So if the students can't come to the laboratory equipment, we might try to bring the laboratory equipment to the student. However in many cases, the equipment is too large and heavy and there is only a limited amount of equipment. So I propose to consider shrinking the equipment to a miniature size, sacrificing some of the functionality, but saving the active learning environment in big classes.

In this hands-on session you will be presented with a number of examples of large laboratory equipment, shrunken to something that students can handle in the class room like (Frenzel, 2012). You will then in the hands-on section present your relevant equipment in groups and be challenged to consider your own courses and laboratories for miniaturization. The outcome of the session should be new and fresh ideas to improve the hands-on part in your courses.

This will need to be followed by a discussion of the problem of the teacher-to-student ratio, which is particularly critical working with hands-on exercises and how to address this. Finally I propose to discuss and evaluate how this affects our teaching style, learning goals and learning outcome.

REFERENCES
Resource area for teaching, *Bridging the Engagement Gap with Hands-On Teaching*, raft.net, Feb 2013
Kolb D.A., Experiential Learning: experience as the source of learning and development, 1984, Prentice-Hall
Honey P, Mumford A, Manual of Learning Styles, 1982, Peter Honey Publications
Frenzel L., *NI miniSystems Teach More Systems Concepts*, Electronic Design, Oct 2012

Want to try out Problem-Based Learning?

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Sabine Schmidt, LearningLab DTU
DTU, Denmark, sabis@llab.dtu.dk

ABSTRACT

Keywords: problem based learning, pbl, learning by doing

Hands-on activity. Limited number of participants: 16-18. No prerequisites required.

Background and explanation:

Problem-Based Learning is becoming an attractive active learning method in an increasing number of universities (Beddoes *et al*, 2010; Galand *et al*, 2012). In Denmark, Aalborg University is using PBL in their engineering programmes (Aalborg University PBL model) and several programmes at university colleges are also using the method. It is a student-centered, problem-centered and group based approach to learning (Lorna Uden and Chris Beaumont 2006; Maastricht PBL model). Working as a student with this approach means that the learning process is much dependent on your own decisions, arguments and interests. As a teacher the PBL process defines an entire new role as a co-facilitator (Lorna Uden and Chris Beaumont, 2006). It is therefore a concept of teaching and learning that is very different from traditional teacher-centered approaches.

In this workshop participants will be introduced to the theories and ideologies behind PBL. The method used in the workshop is PBL; this means that we will ask participants to solve a problem by using PBL. This way, participants will be given a platform to get into the ideas behind PBL by trying it out themselves, thus encouraging the use of this active learning method in their own teaching onwards.

If participants are motivated by the ideas behind PBL after this workshop and are eager to knowing more about how to design good problems the advanced PBL workshop: “When a good problem is key to success” is recommended.

Set-up

The workshop will have a short introduction to the concepts of problem-based learning and the resulting new roles of teachers, students and required organizational support. To fully get into the central ideas in PBL, participants are asked to work intensively in groups with a relevant problem, using the PBL approach with the support of a tutor. In plenum experiences of working with the described steps of the method will be discussed and elaborated on. Time for personal reflection allows participants to draw conclusions for their own teaching and possible implementation steps. As a recap in the end of the workshop a reflective, activating method will be used for workshop evaluation.

Expected outcomes / results:

After the workshop participants are able to

- Define the 7 steps of PBL defined by Maastricht University
- Identify and discuss benefits and challenges of PBL
- Describe a PBL implementation process on a basic level

REFERENCES

Beddoes, K.D., Jesiek B.K., Borrego, M (2010). Identifying Opportunities in Collaborations in International Engineering Education Research on Problem-Based Learning. *Interdisciplinary Journal of Problem-Based Learning*, 4(2)

Galand, B., Frenay, M., Raucent, B. (2012). Effectiveness of problem-based learning in engineering education: A comparative study on three levels of knowledge structure. *International Journal of Engineering Education,* 28(4)

Aalborg University PBL model: http://www.aau.dk/om-aau/aalborg-modellen-problembaseret-laering

Lorna Uden and Chris Beaumont, "Technology and Problem-Based Learning", Information Science Publishing, 2006

Maastricht PBL model:
http://www.maastrichtuniversity.nl/web/Main/Education/ProblemBasedLearning.htm

Method for constructing test questions of a new innovative item format

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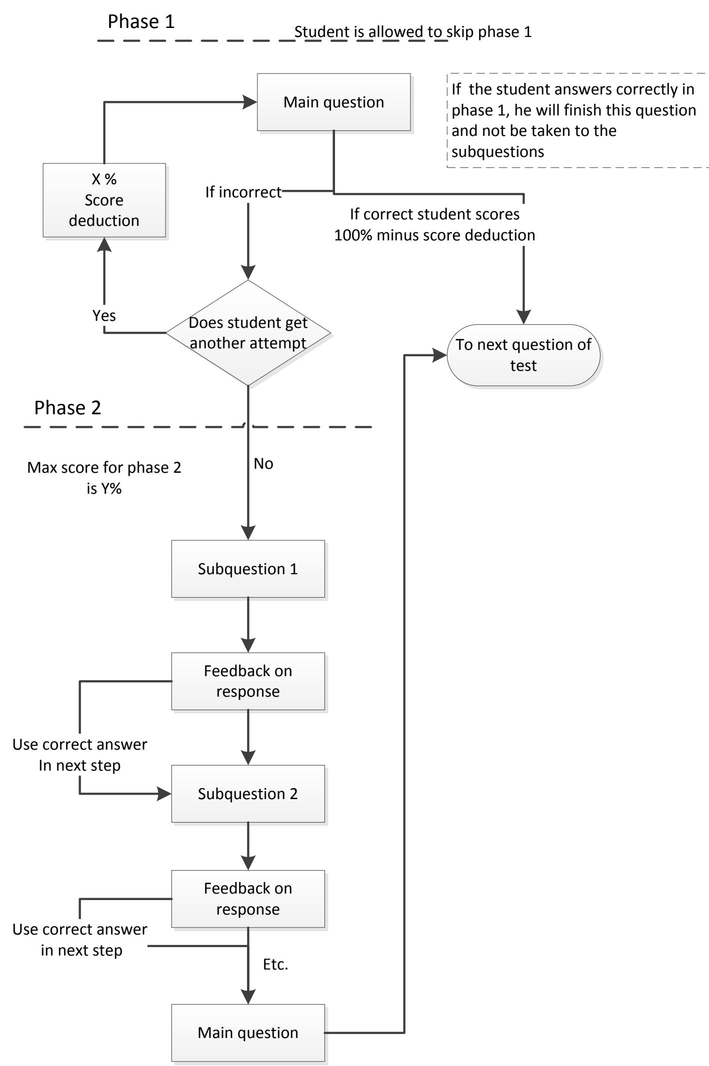
Keywords: construct representation, innovative item format, digital testing, Engineering education

Digital testing is increasing rapidly and new innovative item formats (i.e., question types) are developed. Generally, innovative item types have the potential to increase construct representation (Sireci & Zenisky, 2006[i]). The innovative item type of our interest is called the “main-sub”. In the main-sub question type, a student is asked to come up with their own strategy to solve a problem. If it turns out that the student is not capable to come up with the correct answer, (s)he is taken to a series of sub questions. In answering these sub questions the student can show what he does and does not understand.

Before the item format “main-sub” can be used on a large scale further research is necessary to establish what the added value is. It is possible that if questions are misunderstood by students there is a discrepancy between what the exam is supposed to measure and what it actually measures regarding content and thinking processes (Leighton, 2004[ii]). The objective of this study is to research to which degree the format “main-sub” is capable to represent the construct. Therefore, the content a teacher intends to measure with the exam is compared with thinking processes of students taking the exam. The targeted domain for this research is Engineering education.



In the hands-on session we will take teachers on the journey of writing test questions in this innovative item format. In the introduction this innovative item format will be introduced. An example of the method to construct a question of this type will be presented. Teachers are asked to bring along one of their own exams, appurtenant answer model, test blueprint if available and answers of students. First, teachers will look at the match between what they intended to measure with the exam questions and what they actually measured. Second, in small groups and with guidance teachers are asked to transfer their ‘old’ questions to the new format. We will conclude the session with a discussion that centres around two points. The view of the teachers on the “main-sub” item format and usability of the method. The input from the hands-on session will be used as input to further improve our method to construct innovative test questions.

The expected outcome of the hands-on session are guidelines on how to construct new questions in the innovative item format and under which conditions.

[i] Sireci, S. G., & Zenisky, A. L. (2006). Innovative Item Formats in Computer-Based Testing: In Pursuit of Construct Representation. In S. M. Downing & T. M. Haladyna (Eds.), *Handbook of Test Development* (pp. 329-348). Mahwah, NJ: Lawrence Erlbaum Associates.

[ii] Leighton, J. P. (2004). Avoiding Misconception, Misuse, and Missed Opportunities: The Collection of Verbal Reports in Educational Achievement Testing. *Educational Measurement: Issues and Practice, 23,* 6-15.
doi: 10.1111/j.1745-3992.2004.tb00164.x

Hands-on Session:

Design Thinking as a tool for the design of Engineering Education

Renate Klaassen & Alexia Luising

Delft University of Technology

Today engineering problems are going from more rational problems to complex and wicked problems. Knowledge and skills are so specialised that not each engineer can be on top of all the required knowledge and skills to solve these problems. Thus engineers are more and more challenged to work in multidisciplinary teams on hybrid problems. To create an educational environment in which the knowledge and skills can be acquired, we as educators should similarly adapt our educational methods for the design of these learning environments. Design thinking for Education offers excellent tools to go through the design cycle visualising and imagining new and innovative educational realities that will address the future of the professional Engineer.

Design thinking is a tool that allows:

- empathy to become leading in exploring new contexts
- creativity of multidisciplinary teams to generate new insights and solutions and
- analysis and assumption testing to find out which solutions work.

Iteration, failing fast and often become key ingredients to find the right mix of educational methods to address the problems future engineers will be facing. In this hands-on pressure cooker session you will redesign your own learning environment for the teaching of future engineers on the basis of a number of design thinking tools and go home with a conceptual idea of what your course could look like in the future.

Sources:

Kamp, A. (2014), Engineering Education in the Rapidly Changing World, Rethinking the Mission and Vision on Engineering Education at TU Delft, Delft

Jeanne Liedtka and Tim Ogilvie (2011), Designing for Growth, Columbia University Press

IDEO, Design Thinking For Educators Toolkit, IDEO Books

The flipped classroom: design considerations and Moodle

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ABSTRACT
One of the novel ideas in teaching that heavily relies on current technology is the "flipped classroom" approach. In a flipped classroom the traditional lecture and homework sessions are inverted. Students are provided with online material in order to gain necessary knowledge before class, while class time is devoted to clarifications and application of this knowledge. The hypothesis is that there could be deep and creative discussions when teacher and students physically meet. This paper presents design considerations for flipped classrooms, and discusses how Moodle can facilitate communication and information sharing in such classrooms. Furthermore, it provides guidelines for supporting out-of-class instruction in the flipped model by using quizzes and feedback in Moodle, and comments on the potential to follow student use of resources by using Moodle reports. This paper concludes with a discussion of the opportunities and challenges when implementing the flipped model in a virtual learning environment (VLE) like Moodle.

Keywords **-** flipped classroom, virtual learning environments, Moodle, quizzes, feedback

I INTRODUCTION

Bonwell and Eison defined active learning as "…anything that involves students in doing things and thinking about the things they are doing." (Bonwell & Eison, 1991). Active learning therefore embraces different instructional models, in which learners are engaged in other activities than just listening – they are encouraged to read, write, discuss and be involved in higher-order thinking. One of the recent developments in teaching, which is also a form of active learning, is the flipped (or inversed) classroom approach (Abeysekera & Dawson, 2015; O'Flaherty & Phillips, 2015). In a flipped classroom the traditional lecture and homework sessions are inverted. Students are provided with online material in order to gain necessary knowledge before class, while class time is devoted to clarifications and application of this knowledge. The course content, which is provided for self-study, may be delivered in the form of video casts and/or pre-class reading and exercises, while class time is mainly used for group work activities (Berrett, Mangan, Neshyba, Talbert, & Young, 2015). The hypothesis is that there could be deep and creative discussions when the teacher and students physically meet.

This teaching and learning approach endeavours to make students owners of their learning trajectories, and relies heavily on current technology. However, the literature has yet to discuss in detail the tools that can facilitate flipped classrooms (Bishop & Verleger, 2013). In this paper, I am going to share our experiences and considerations in using Moodle for implementing a flipped classroom in engineering mathematics (Triantafyllou, Timcenko, & Busk Kofoed, 2015). The paper presents design considerations for flipped classrooms, and discusses how Moodle can facilitate communication and information sharing in such classrooms. Furthermore, it provides guidelines for supporting out-of-class instruction in the flipped model by using quizzes and feedback in Moodle, and comments on the potential to follow student use of resources by using Moodle reports. This paper concludes with a discussion of the opportunities and challenges when implementing the flipped model in a virtual learning environment (VLE) like Moodle.

II BACKGROUND WORK

The flipped classroom is a relatively new pedagogical approach, which has gained momentum in the last years. There have been various attempts to apply the flipped classroom in educational environments. For example, Love and Hodge compared a classroom using the traditional lecture format with a flipped classroom during an applied linear algebra course (Love, Hodge, Grandgenett, & Swift, 2014). Students in the flipped classroom environment had a significant increase between the sequential exams compared to the students in the traditional lecture section, but they performed similarly in the final exam. Moreover, the flipped classroom students were very positive about their experience in the course, and particularly appreciated the student collaboration and instructional video components. Strayer compared a flipped statistics class with a traditional one (Strayer, 2012). He found that although students in the flipped classroom were less satisfied with classroom structure, they became more open to cooperative learning and innovative teaching methods.

However, there are also critics to this approach (Kellinger, 2012; Nielsen, 2012). Concerns include among others: criticism about the accessibility to online instructional resources, the growing move towards no homework, increased time requirements without improved pedagogy, teachers concerns that their role will be diminished, lack of accountability for students to complete the out-of-class instruction, poor quality video production, and inability to monitor comprehension and provide just-in-time information when needed. As a response to such concerns, researchers have proposed hybrid models of the flipped classroom. For example, the in-flipped classroom is designed to be a learning environment that consists of real and virtual teachers in the same classroom (Chiang & Wang, 2015), while the holistic flipped classroom has teachers offering synchronous support to students both in and out of the classroom (Chen & Chen, 2014).

Besides critics, other researchers have noted that more research is needed on the flipped classroom in order to develop its theoretical foundation and to evaluate its contribution to the development of lifelong learning and possibly other skills (Abeysekera & Dawson, 2015; O'Flaherty & Phillips, 2015). In our research in the Media Technology Department, we have adopted the flipped classroom instructional model inspired by the Problem-Based Learning pedagogy, which Aalborg University applies to all its programs. The next section discusses this theoretical framework, which we employed for designing the flipped classroom and the related out-of-class and classroom activities.

III PROBLEM-BASED LEARNING AND THE FLIPPED CLASSROOM

In the literature, there have been used various theoretical frameworks to justify the flipped classroom and support the design of in- and out-of-class activities. Such theoretical frameworks typically argue for the benefits of student-centred and collaborative learning (e.g. active learning, problem-based learning, peer-assisted learning).

The research presented in this paper is guided by the Problem-Based Learning (PBL) pedagogy, which is applied at Aalborg University since its establishment in 1974 (Barge, 2010). PBL is a student-centred instructional approach, in which learning begins with a problem to be solved. Students need to acquire new knowledge in order to solve the problem and therefore they learn both problem-solving skills and domain knowledge. The goals of PBL are to help the students "…develop flexible knowledge, effective problem solving skills, self-directed learning, effective collaboration skills and intrinsic motivation." (Hmelo-Silver, 2004).

At Aalborg University, PBL is also combined with group work (Kolmos, 1996). While working in groups, students try to resolve the problem by defining what they need to know and how they will acquire this knowledge. This procedure fosters the development of communication, collaboration, and self-directed learning skills. Moreover, group work in PBL may enable students to experience a simulated real world working and professional environment, which involves process and communication problems and even conflicts, which all need to be resolved to achieve the desired outcome.

Additionally, PBL represents a paradigm shift from the traditional one way instructional methods. In PBL, the teacher is not an instructor but rather a tutor, who guides, supports, and facilitates the learning process. The tutor has to encourage the students and increasing their understanding during the problem-solving process. Therefore, the PBL teacher facilitates and challenges the learning process rather than strictly transmitting domain knowledge.

Therefore, the flipped classroom that employs computer-based individual instruction outside the classroom and devotes classroom time to group activities with the teacher as facilitator is well justified by the aforementioned principles of PBL. The goal of a flipped classroom is to let the student study individually at her own pace while providing the appropriate support material for out-of-class instruction and then come into class, where groups of students engage in group activities facilitated by the teacher. Therefore, we decided to introduce the flipped classroom approach in mathematics related courses for Media Technology students for aligning them with the PBL pedagogy. The following section presents design and implementation considerations for a flipped classroom based on the experience of implementing the flipped instructional model in the Media Technology Department.

IV DESIGN AND IMPLEMENTATION OF A FLIPPED CLASSROOM

In a flipped classroom the traditional lecture and homework sessions are inverted. Students are provided with online material in order to gain necessary knowledge before class, while class time is devoted to clarifications and application of this knowledge. After class sessions, students may need to reflect on their practice or complete assignments given during class time. Figure 1 shows the flipped classroom framework. As literature has discussed, this generic framework allows for many different implementations depending on different class designs (Bishop & Verleger, 2013). In the following, several design considerations for each phase of a flipped classroom are discussed.

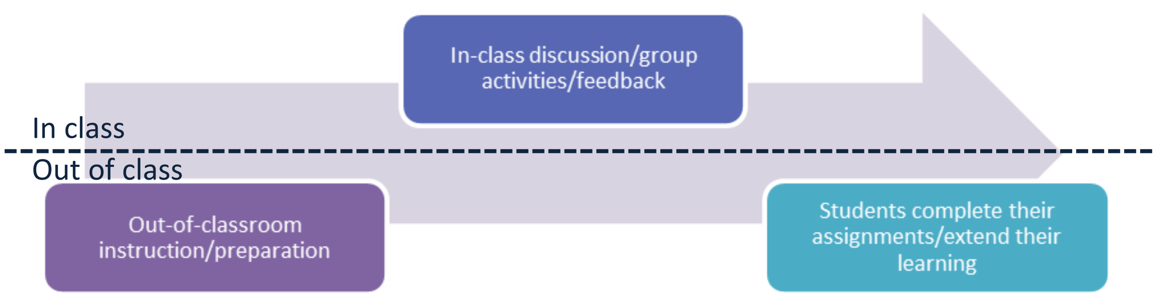

Figure 1. The flipped classroom framework

Out-of-class instruction

Instructors who wish to flip their classrooms should first decide how to distribute the learning process in the three phases of the flipped classroom framework. Initially, it is important that they consider which part of the lecture can be accomplished best online, which part can be accomplished best in class sessions, and possibly which part after class. When this distribution is done, instructors should decide how content can be delivered to students outside of class in meaningful ways. Educators have been employing different tools in order to deliver material out of class. Examples include problem-solving sessions as pencasts, screencasts, parts of lectures as vodcasts (video podcasts), reading, online resources, and illustrations. Finally, they should implement the material for out-of-class instruction.

Another important aspect of out-of-class instruction and preparation is how to support students to self-regulate their learning and how to motivate students to complete their pre-class assignments. For supporting students during their self-paced learning, educators have employed feedback forms, online chats, forums among others. Such tools allow also teachers to adopt the in-class activities to students needs and difficulties. In order to ensure that students come to class prepared, instructors have used exercises, (online) diagnostic tests, and (obligatory) hand-ins. A more detailed discussion on out of class instruction can be found in (Triantafyllou & Timcenko, 2015).

Class sessions

Since at least a part of traditional lectures is transferred out of class, the class sessions shall be also reorganized. First of all, it should be considered how much time should be allocated on hands-on learning activities, how much time on lectures (if any), and what should be the teacher's role in the class. Moreover, in-class activities should be designed with the aim to encourage meaningful learning and engage students, and they should be integrated with out-of-class activities for optimal learning. On the practical side, it should be also considered if and which tools are necessary to use in order to support this new learning environment in class.

Research has shown that an important consideration for instructors is how to handle students who come to class unprepared. Ill-prepared students cannot participate meaningfully in class practice, and this can be very frustrating for their peers, especially when learning activities are carried out in groups. The solution to this problem depends heavily on the educational level where the flipped instruction model is applied, since there are different expectations depending on student age. Possible solutions include assigning different activities to ill-prepared students or requiring them to carry out the out-of-class preparation in class.

After class

After class sessions, the instructors may choose to require students to carry out supplementary activities. Post-class activities could be a continuation of what was done during class time (e.g. finalize in-class activities) or additional activities. In this case, activities may be used in order for students to check their understanding and/or reflect over their own practice. Finally, educators should decide if student assessment is affected by the new instructional approach. For instance, they should consider if diagnostic tests and in-class assignments are part of the assessment. If this is the case, then they should also consider how students are assessed based on such activities and how ill-prepared students are handled.

The flipped classroom in Media Technology

In the Media Technology Department, the flipped classroom was implemented for several mathematics-related courses. Regarding out-of-class instruction, pencasts, vodcasts, reading, and online resources have been employed for different implementations, and diagnostic tests were used in order to encourage students to complete their out-of-class preparation. During class sessions, group activities, feedback sessions and lecturing have been used for completing the learning process. Ill-prepared students were asked to study the online material, if they could not follow the class activities. Finally, students were required to upload their in-class activities after class, in order for the teachers to check their progress. Both diagnostic tests and in-class activities were part of the assessment. The communication between students and teachers and information exchange were facilitated by Moodle (Dougiamas & Taylor, 2003). Moodle is a learning platform designed to create personalised learning environments and is used by all programs at Aalborg University. The following section reports parts of this learning platform, which can be used for facilitating a flipped classroom.

V MOODLE AND THE FLIPPED CLASSROOM

Moodle is a VLE that acts as a communication channel between teachers and students. The simplest use of Moodle is information sharing, such as file-sharing, calendar, and announcements. It is therefore a platform for information exchange (e.g. sharing of vodcasts and reading material) in flipped classrooms. Apart from that, Moodle can provide information to teachers and host educational activities, which are also relevant for flipped classrooms. In the following, two Moodle activities are presented and their application on flipped classrooms is discussed. The information mentioned in this paper refers to Moodle's version 2.

The Moodle quiz

The Moodle Quiz allows teachers to design and build quizzes consisting of various question types, including multiple choice, true-false, essay, matching, etc. Questions can be randomly selected from question pools already created in Moodle and they can also be imported from other sources, e.g. various formats that book publishers use and text files. The teachers are also able to shuffle the questions in a quiz, if desired. Therefore, it is applicable to a wide range of subjects, allowing for various types of questions and answers.

The Moodle's quiz module has a large number of options that make it extremely flexible. Teachers are able to set time limits for an attempt to be completed, and also open and close dates and times for the quiz. This option allows teachers to be sure that diagnostic tests are taken and submitted before the class in the flipped instruction model. Moreover, teachers are able to enter feedback both for each answer (either correct or wrong) and also general feedback, when the attempt is complete. Feedback can guide students while trying out the quiz or between subsequent attempts, if this is allowed. By providing feedback adapted to each student's answers, teachers can support students during out-of-class instruction and also monitor comprehension and provide just-in-time explanations. Moreover, they can include in the in-class activities topics, which students found challenging based on the quiz results. Finally, students can self-regulate their learning, since they can check the correctness of their answers, and the knowledge that they are expected to have before class.

Regarding assessment, Moodle allows the teacher to assign point values to each question and weight each question in the quiz. Moreover, teachers may award partial credit to other answer choices (apart from the correct one), if desired. Finally, teachers may give individual students a different open/close period, time limit and/or number of attempts than the rest of the class. These features provide customization options to teachers that may be needed in out-of-class learning environments.

The Moodle feedback

The Moodle feedback activity allows teachers to create student surveys. It has several features that make it adjustable to different purposes. First of all, responses can be anonymous, and it is possible to allow more than one submission per person. Moreover, it is possible to define an open/close period and to request feedback in different forms (e.g. multiple choice questions, text answers, numeric answers). Finally, it is allowed to have branching questions, i.e. questions that only display if the user answers another question in a certain way.

The feedback module is ideal for requesting feedback on the out-of-classroom activities (pre- and post-class), but it can also be used to stimulate students to brainstorm or sharing ideas on any other related topic (e.g. what was the most interesting thing you learned today). Moreover, it allows students to send questions they may have during out-of-classroom preparation, possibly alleviating the feeling of lacking just-in-time explanations. The feedback activity in Moodle can also be employed to gather student opinions on the course as a whole or on specific topics, activities or aspects within it.

Moodle reports

Moodle can generate reports for each course. Reports can contain a) a log of activity in a Moodle course for various periods, b) a course activity report, showing the number of views for each activity and resource, c) a participation report for a particular activity, and d) graphs and tables of user activity. The Moodle reports allow teachers to know you what students have been doing in their Moodle courses. For example, they can get information on which pages they are accessing, the times at which they access them and the activities they perform there.

In a flipped classroom, reports can be a valuable tool for the teacher, since a huge amount of information is provided to students online. By using reports, teachers are able to alert students or improve navigation to course material they are neglecting, in order to make sure that they take full advantage of all the online resources provided. Moreover, they can adjust the course to suit students' viewing habits. Finally, course activity reports can be used to get insight on student participation and engagement in a flipped classroom.

VI DISCUSSION AND CONCLUSION

In this paper, we have discussed various design considerations for flipped classrooms and we have mentioned features of a VLE, i.e. Moodle that can be used to support such classrooms. Quizzes can serve as motivation and self-control tools for students during pre- or post-class activities. Moreover, they allow teachers to get insight into students' common mistakes and adjust their class sessions accordingly. Feedback activities (i.e. surveys) can stimulate students to reflect on their own practice and also to post questions to the teacher before or after class. Moreover, they can serve course evaluation purposes, by gathering student opinions and experiences. Finally, Moodle reports provide teachers with usage data and activity logs, which are useful for checking student behaviour during out-of-class time and improving the way information is transmitted. There can also be valuable course evaluation tools.

However, the implementation of a flipped classroom in Media Technology has shown that there are also challenges, when a VLE is used as a communication channel between teachers and students. Initially, there were problems uploading instructional videos in Moodle and also issues with videos in Moodle playing only once. These problems demotivated students and created confusion among them (Triantafyllou et al., 2015). Moreover, the literature and our experiences indicate that students do not use Moodle as a communication channel but mainly perceive it as a repository of learning materials, despite its great potential (Costa, Alvelos, & Teixeira, 2012). It is therefore recommended that educators, who aim at implementing flipped classrooms in Moodle, introduce the possibilities of this environment to students and provide clear guidelines on how it will be integrated to the new instructional model.

This paper has discussed opportunities and some challenges of using Moodle in flipped classrooms. It has been shown that this VLE can support student and teacher practice in such classrooms and it can facilitate communication between them. However, limited student use of Moodle and technical problems may hinder the acceptance of such tools. It would be therefore interesting for future research to investigate how teachers and students experience such learning environments in flipped classrooms, and which factors are decisive for creating positive attitudes towards their use.

ACKNOWLEDGEMENTS

I would like to thank the teachers and students in the Media Technology Department, which were involved in the flipped classroom project for their valuable help.

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BIOGRAPHICAL INFORMATION

Evangelia Triantafyllou received the M.A. degree in Electrical and Computer Engineering at Aristotle University of Thessaloniki, Greece, in 2000 and the PDEng (Professional Doctorate in Engineering Design) degree in ICT at Eindhoven University of Technology, The Netherlands, in 2004. She subsequently worked as a computer science teacher on various educational levels. In October 2012, Evangelia was appointed as a PhD Fellow in the Department of Media Technology at Aalborg University Copenhagen, Denmark. Her PhD project is entitled "ICT-based teaching methods for improving mathematics learning for Media Technology students: Investigation and findings" and her research interests include technology-enhanced learning in mathematics, active learning and university mathematics education.

When a “good” problem is key to success…

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Keywords: problem-based learning, problem design, ill-structured problems, instructional design

Type of submission: hands-on activity

Prerequisites: required - basic knowledge about PBL OR participation in workshop “Want to try out Problem Based Learning?” (day1) (PBL implementation experiences optional)

Background

Problem-based learning (PBL) is due to its many benefits increasingly implemented in engineering education during the last years (Beddoes *et al.* 2010, Galand *et al.* 2012, Strobel *et al.* 2009). In several scientific articles factors were identified which influence effectiveness of PBL (Hung 2011, Hung 2013, Masek *et al.* 2010, Peterson 2004). This hands-on workshop aims on addressing on one of the major factors for effective PBL: the design of ill-structured problems.

Explanation

A well-designed ill-structured problem is one key to a successful implementation of PBL (Hung 2011, Hung 2013, Masek *et al.* 2010, Peterson 2004). Thus, this workshop will contribute to student’s activation and increased learning by enabling teachers to design better suited problems for PBL. By using a very activating, hands-on workshop design participants will experience an exemplary problem design process. The workshop is based upon a literature review of recommendations for problem design in PBL (Dolmans 1997, Hung 2011, Jonassen *et al.* 2008). Participants will together create ideas on how to face practical challenges in the problem design process. To increase learning of the participants dedicated reflection time allows them to draw conclusions for their own teaching.

Set-up

When signing up participants are asked to fill out a short, on-line questionnaire about their prior knowledge and practical experiences with PBL. Results will be used for detailed workshop design. They are expected to prepare beforehand with material provided (approx. 30min). The interactive introduction will use concept questions and peer teaching to build a common base. Afterwards participants will design problems in small groups using a form which will be provided by the workshop facilitators. In the plenum experiences on applying design principles will be shared. Ideas of how to face challenges in the design process will be developed. Time for personal reflection allows participants to draw conclusions for their own teaching. A reflective, activating method will be used for workshop evaluation.

Expected outcomes / results

After the workshop participants are able to:

- define principles for the design of ill-structured problems used in PBL,
- apply design principles on one exemplary problem,
- list challenges of problem design and identify possible solutions,
- conclude possible next steps for their own teaching.

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Self-education - learning by sharing and doing

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The type of contribution I am submitting: _X_ hands-on, ___explore, _____poster.

ABSTRACT

Keywords - maker space, active learning, motivation

Background: The background for this article is to examine, how it is possibly to increase student's active learning by making a learning environment where motivation can flourish. It is my belief, that group activities can motivate the students by making it possible for them to share thoughts and gain new relationships. A makerspace may encourage creativity and exploration and students can learn new skills from other makerspace members. The students learn how to combine theory with practice in a learning by doing environment where it is possibly for them to take ownership of personal or collaborative projects.

Explanation: The aim is to establish a learning environment where students can engage in and develop new ideas together. It is seen that makerspaces can lead to high level of responsibility and project ownership where students can focus on step by step learning rather than just performance (Harnett et al. 2014). The makerspace at ASE is inspired by an organization climate where students are trusted and it is believed, that they perform best while given freedom and space to use their own judgement. This can lead to positive motivation (Biggs & Tang p.40-43). Students can be motivated in many ways by working with problem-based activities (Ibid p.34-35). A maker space may provide a framework for extrinsic, social, achievement and intrinsic motivation and thereby making higher level learning possible. To create a learning environment where students can use their creative skills, it is necessary to allow the students to dare to take risks and try to use their knowledge in new ways. It is important that teachers don't stifle the students creativity by determine the outcome of their projects or focusing more on the end goal than the development process (Ibid p.170-173). To work creative is important but it is essential that engineering students learn that designing is a complex process demanding a high cognitive level. This can be realized through problem based learning (Dym et al 2005).

Set-up: The participants will be presented with ASE´s current framework for its makerspace and some of the results from different makerspace activities. The hands on session will be at structured discussion based on a discussion sheet on how to create an interdisciplinary community for education based on the maker philosophy. When creating a makerspace there are some question that need answering e.g. payment for consumables for lab equipment, use of lab equipment for privet use and top down or bottom op management. The participants will address these and more topics in groups and discuss their findings with a peer group.

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The Study Activity Model SAM - Enhancing Active Learning?

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ABSTRACT

Keywords – study activities, active learning, curriculum development. **Hands-on**

Background

Active learning is a beneficial teaching and learning approach (Freeman et. al 2014) where students are actively engaged in learning by doing. This approach to teaching and learning changes the role of the teacher, from the 'sage at the stage' to the 'guide at the side'. This role shift may meet with resistance but one way of overcoming the resistance is to use the Study Activity Model (SAM) developed by the Danish University Colleges, to visualize that students' learning processes can be supported by a number of different types of study activities not all of which require the active presence of the teacher.

Figure 1. The Study Activity Model SAM (Mølgaard, 2014, page 9)

The aims of this hands-on session is 1) to familiarize participants with the SAM model, 2) to assess and discuss implications of the SAM model, and 3) to discuss the usefulness of this tool in curriculum development at different levels. The session is suitable for both teachers and study planners.

Explanation

Participants will use the SAM model to analyse own teaching, whether at programme, semester or module level.

Set-up

Participants are requested to bring along example(s) of own programmes, semester plans or module plans for analysis.

Expected outcomes

Participants will gain knowledge about a model that may be useful in study planning and curriculum development.

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Teaching Engineers Innovation Competencies

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ABSTRACT

Keywords – innovation competencies, teaching formats, transformative learning

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

In the engineering education we experience a growing focus on stimulating innovative and interdisciplinary competencies among our students (Liebenberg & Mathews, 2010) in order for our students to acquire the needed 21st century skills (King, 2007). But these skills entail a change of behavior exemplifying the need for transformative learning (Illeris, 2004).
Innovation competencies seen as "*the ability to create innovation by navigating together with others under complex situations." (Darsø, 2001)* entails an awareness of both own competencies and knowledge as well as of the others. This workshop will include trying out some of the formats that we use in teaching to stimulate this awareness in engineering students.
These formats are both used in the study programme in Process and Innovation Engineering and acts as pilots towards a huge initiative at DTU starting in the Autumn of 2016. Here all bachelor of engineering students will on their 5th or 6th semester go through a 10 credit interdisciplinary innovation module.

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Supplemental Instruction (SI) Collaborative peer learning

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ABSTRACT

Active participating collaborative peer learning

I INTRODUCTION

Supplemental Instruction (SI) is an academic support program that aims at increasing student success in "difficult" courses (M. Hurley, G. Jacobs, and M. Gilbert, "The Basic SI Model",2006). SI was developed at the University of Missouri in Kansas City in the early seventies and has since spread to over 1500 universities and university colleges in nearly 30 countries (D. Martin, "Foreword," Australian Journal of Peer Learning Vol. 1, pp. 3-5, 2008.) It was implemented in Sweden and Lund University 2004 and Lund University serve as and Scandinavian centre for SI.

The main component of SI is an informal collaborative learning environment under the guidance of a "senior" student. This SI leader is a student who has previously completed the course successfully and can therefore act as a model student. The role of the SI-leader is not that of a teacher – they do not impart new knowledge. Instead the SI leader facilitates the process of understanding difficult course material.

It generally commences in a relatively easy-going fashion with some 5-10 minutes of talk, guided by the SI leader (the SI-leader is usually a 2^{nd} or 3^{rd} year student) about occurrences in the course during the previous week. Thereafter the participants decide which areas they want to focus on during the SI session –concepts that need clarification, or problems that have been difficult to understand and solve. The SI leader usually divides the group into smaller sub-groups to ensure that all participants may be active and able to contribute to the work with the material. The SI leader's main task is thereafter to act as a facilitator to ensure that the work and discussions in the groups progresses smoothly. This is done for instance by asking or redirecting questions within the group, helping to break down problems, and encouraging participants to help each other towards understanding, by posing critical or probing questions. It is essential that the SI leader works to obtain an open climate in the group whereby all participants are free to ask the questions they would like to have answered. The SI sessions are generally concluded with the participants presenting for each other, the solutions and answers they have arrived at, using the blackboard.

Hands on Session

This hands on session will demonstrate some strategies in a SI session and will involve participant in the activity and will then provide an open discussion about what occurred in the session. This hands on session will also will provide the participant with an understanding of the role of the SI-leader, what strategies that can be used and also learn what outcomes the SI participant will get by taking part in a SI session

Help to recruit the future Engineers

– And learn how to activate learners through Design Thinking

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ABSTRACT

Key words: Future Engineers, Design Thinking, Problem based learning, Active learning, Innovation.

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

Background

One of the greater challenges an educator face is inactive or demotivated learners. Learning will not occur unless the learner is actively involved in the learning process in one form or other. It can be discussed whether learners at higher educational institutes can be expected to be self-motivating and active learners. But regardless of what position educators take in terms of expectations to the learner's engagement, the didactic methods applied in the learning situation can either catalyse or prohibit activation and engagement of the learner.

For this reason every educator should ideally be familiar with active learning tools and be enabled to implement them in learning processes to the extent that is found meaningful.

Set-up

During the hands-on session the participants will initially be introduced to the 5 stages of Design Thinking as they are defined at Institute of Design at Stanford University.

1: Empathize
2: Define
3: Ideate
4: Prototype
5: Test
(http://dschool.stanford.edu/redesigningtheater/the-design-thinking-process/)

For the hands-on session a challenge is posed:

"How can we, inspired by active learning processes, support teachers at elementary level in primary schools (grade 0-4) in the development of pupil's motivation to and capabilities of becoming engineers, hereby ensuring a solid scientific foundation and motivation that will enable and catalyze application for an engineering degree."

Participants will work through the five phases of Design Thinking and, in teams, create potential solutions to the challenge at hand.

The last 20 minutes of the session is going to be used for evaluation of the design thinking process and for participants to share their thoughts on when, how and where they could use this type of active learning process in their own educational practice. This has the purpose of giving the participants an opportunity to reflect on their own learning and inspire each other with possible ways to implement design thinking in engineering education.

Expected outcomes/results

At the end of the hands-on you have had the chance to explore how to work with the Design Thinking process yourself. On top you have come up with a concept to support the acquisition of future engineers.

It is expected that the learning outcome of a learning sessions where Design Thinking is used as process methodology reaches level 4 on the SOLO taxonomy (Biggs, J; Collis, K. 2014), complex use at an extended abstract level, the learner is expected to use their own resources and create. Depending on the framing of a Design Thinking process there is an opportunity to reach the highest levels of learning, according to Per Erik Ellström, developmental learning either on the productive type 2 level or the creative level, depending on whether the problem is given or not (Ellström, P.2001).
The more you empower students in the learning process the greater the learning potential is, due to the fact that the boundaries are not restricted by the curriculum

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Abstracts/Papers
Explore Sessions

Active Learning in Sustainability Teaching

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Type of contribution **-** explore

Keywords – quantitative sustainability assessment, company, project, assessment, assignment, life cycle assessment

BACKGROUND

Societies are increasingly faced with the need to address global sustainability challenges, such as climate change, resource depletion or chemical pollution, to name but a few. Immediate reductions in the environmental footprint of human activities are therefore necessary. To do so, tools that allow for quantifying sustainability and guiding management actions associated with decisions and policies taken by stakeholders in industry and authorities should be systematically used.

The awareness of these challenges and needs is a key point in the education of future engineers. When entering the labour market and due to their influence as builders of tomorrow's societies, they must (1) know what sustainability is and how their decisions as engineers can affect sustainability, (2) be aware that there are methods and tools to assess the sustainability of their decisions, and (3) for those specialized in innovation and technology development, understand the principles of sustainability assessment and be able to apply tools for quantitative sustainability assessment.

However, how to optimise the teaching to increase the student learning and thus achieve these objectives? We posit that active learning has a central role to play, and we aim to explore opportunities for active learning in different course settings.

EXPLANATIONS

Teaching quantitative sustainability aspects implies specific challenges as the learning relates to (1) background knowledge about sustainability across its various dimensions, (2) the standardised assessment methodologies (e.g. EC, 2010; ISO, 2006) and their applications, and (3) the (further) development of these methodologies. Three levels of learning have thus been defined, each covering the entire ranges of the Bloom's taxonomy but with different emphasis (Bloom, 1984; Olsen, 2010):

1. LEVEL 1 "basics and principles of sustainability assessment in engineering": Teaching of methods and tools for sustainability assessment targeted at different technological domains, providing a background knowledge to students pursuing a career in various technical fields (Bloom's level I-VI – with emphasis on levels I-IV – Know, Comprehend, Apply and Analyze)
2. LEVEL 2 "advanced application of quantitative sustainability assessment methods in engineering": In-depth education for the students aiming to work with the development of technical solutions and therefore wishing to acquire in-depth knowledge of the tools available to assess sustainability of technologies (Bloom's level I-VI with emphasis on levels III-VI – Apply, Analyze, Synthesize, Evaluate)
3. LEVEL 3 "expert training in developing quantitative sustainability assessment methods in engineering": Specialized teaching and education of principles and methods for quantitative sustainability assessment targeted at the student pursuing a professional career within this field (Bloom's level I-VI with emphasis on levels III-VI – Apply, Analyze, Synthesize, Evaluate, Create)

Because of the technical level of the standardised assessment methodologies, hands-on practice must be an essential part of the learning. A number of methods for implementing active learning in this context have been elaborated and tried out, such as conducting case studies by the students in collaboration with companies (e.g. Hauschild et al. 2012) and the use of peer-assessments that can accommodate large classes (e.g. Edström and Kuttenkeuler, 2014; Christiansen, 2015).

SET-UP

The programme will include introductory presentations to provide a background on the objectives of the session and provide a brief, non-exhaustive overview of existing active learning tools. It will be followed by a workshop session, which will aim at outlining complementary "active learning tools", thus contributing to building an "active learning toolbox" dedicated to quantitative sustainability teaching. A detailed programme is proposed below.

Time	**Activity**
0-5 minutes	Introduction, objectives and expected outcomes
5-20 minutes	3 key presentations, describing current use of "active learning tools" (invited speakers)
20-65 minutes	"Hands-on" workshop session with groups of 3-4 (number of groups conditioned by number of participants). Each will be assigned one of the three learning levels, with a "blank course archetype" as support. The aim of the workshop will thus be for the participants to start from those "course archetypes", and elaborate and discuss suggestions on how to use and implement active learning/teaching.
65-90 min.	Wrap-up of "hands-on" workshop session and plenum discussion

EXPECTED OUTCOMES

The expected outcomes are an "active learning toolbox", gathering a number of tools dedicated to sustainability teaching and usable at different learning levels. They should cover all course elements, from lecturing, assessment, project work. This tool box will be made available to all participants following the workshop, e.g. it is intended to be used to refine existing courses at the Technical University of Denmark.

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Teaching relational understandings of sustainability in engineering education

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ABSTRACT
Sustainbility as relational quality, sustainability as technical parameter, sustainability as disruptive challenges

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

Background
Sustainability is often in engineering curricula reduced to be an immanent parameter of the choice of engineering solution and as such treated in the same manner as other characteristics like price, strength, surface quality etc. While some sustainability issues are straightforward and can be treated as immanent to a given product (fx the use of fossil fuels), many other aspects of sustainability are features of the relational context of the engineering solution. One example is that the importance of non-fossil energy consumption depends to a wide degree on the type of energy source and the availability of this source in specific locations. Another example is how the importance of material composition depends on the expected lifetime and the fate of the materials in the local end-of-life system.

Explanation
Such idealised and abstract descriptions where the contextual relations of production, use and disposal systems are omitted, lead to a fragmented understanding of actual sustainability challenges. On the positive side such parametric descriptions of sustainability issues make them comparable to other disciplines like material science, where a very extensive parameterisation already exists. Accordingly, the parametric sustainability descriptions of LCA have succeeded in developing into a well-recognized technical field, which now appears with the characteristics of an established scientific discipline. However, treating sustainability as an additional parameter, which has to be prioritized alongside other requirements, leaves little room for addressing more radical sustainability challenges.

An alternative to this is to describe the sustainability challenge as the identification of disruptive possibilities that can challenge the current unsustainable regimes of consumption and production. This paper explores how such alternative descriptions are pursued in different courses of the Sustainable Design engineering program at Aalborg University. These approaches include meta-descriptions of sustainability assessment methods, descriptions of technology as elements in socio-technical regimes, descriptions of technologies as interlinked with social practices, and descriptions of consumption dynamics through the use of business models.

Expected outcomes
The paper informs a discussion on how such contextual methods can be combined with more immanent approaches to sustainability and contributes to a further identification and qualification of the sustainability agenda as different from the conventional engineering target of improved efficiency in engineering curricula.

Learning how to apply complex abstract models in the biomedical domain by stepwise reflection.

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ABSTRACT
Keywords: Reflective learning, collaborative learning, higher education - Type of contribution: explore.

Background

Students at higher educations can have difficulties in understanding details and applications of abstract concepts and complex models, due to knowledge gaps and misconceptions (Sotos et. Al, 2007). Within the field of biomedical engineering an example of complex material are the eHealth standards and complex abstract models that are used in the healthcare sector to reach national and international visions of interoperability. It is important that Biomedical Engineering students understand the span and application of these standards and models, in order to be able to apply them correctly when they are enrolled. Typically, the students get to a point where they are able to argue for the overall need for and high-level objectives of the models, but as a learning outcome they must also be able to apply appropriate methods in information system development and select appropriate models for a given context. In (Ertmer & Newby, 1996) it is argued that reflection during the learning process is essential in sophisticated learning. Therefore, we have developed a method, which encourage students to reflect on the applicability of these models, and at the same time allow teachers to assess the students more fine-grained knowledge on the details of the models and standards they have been teaching. Combining design, evaluation-, and collaborative learning techniques has inspired the method outlined.

Explanation of method and setup

The first setup of this method was conducted in the spring 2015 semester on biomedical engineering students in the first year of their master. In groups of 3-5, students were asked to collaborate on prioritizing a set of pre-defined visions for eHealth, and formulate roadmaps for reaching their prioritized visions. The objective was to get students to demonstrate their knowledge on the application of the standards and models they have been taught in the context of healthcare sector. The group work and discussion approach require students to use their knowledge on both theory and context to sketch and argue for an appropriate solution, as shown by (Gokhale et al., 1995). The three-step method include:

1. *A card sorting session.* Here, the pre-defined eHealth visions was prioritized to motivate the students to discuss, reflect and argue about what visions they found important and realistic to implement.
2. *A road map design session.* The students were asked to develop a road map for how to reach their top two prioritized visions. This work was supported by a set of questions to scope the content of the roadmap.
3. *A discussion session.* Each group presented their prioritization and their two roadmaps.

Results

Our early experience is that this three-fold approach engage students and force them to discuss complex material in a more detailed manner and from a more pragmatic viewpoint than what we have experienced earlier. Instead of having students explain the theoretical potential of a standard or model, students were more arguing for what it would take to actually reach the objectives formulated in the vision cards, in the context of the Danish healthcare sector. This also enabled us, as teachers, to gain insight to knowledge gaps and especially awareness about the students' actual learning outcome. Further use of this method and more structured evaluation of this will allow us to present further results on the applicability of this method.

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Detective work: Supporting engineering students' learning when reading scientific texts

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ABSTRACT

Keywords – active learning, reading, research based teaching.

When students begin their master studies, one skill that needs to be enhanced, is their ability to read, understand and explain scientific texts within their chosen field of study. The lecturers have the challenge of speeding up this process because it is the foundation of most learning at master level. The aim of this study was to develop a method to make scientific reading a problem solving and explaining activity to fit the learning styles of the typical engineering students. In our method, detective work, questions concerning a specific scientific article are formulated by the lecturer beforehand. We suggest that the questions are characterized by not require an overview of the text beforehand, and either relating to student's prior knowledge or being explanatory. In the session where the questions are answered, we suggest using teamwork and competition to motivate students. In the spring 2015, biomedical engineering master students completed a detective work sessions about big data in health. The results showed that students engaged actively in the detective work sessions. Student feedback suggested that student leaning was a mixture of deep leaning and surface learning, and consequently they had to engage in further learning activities after the session. Exam results showed that 80% of students received maximum points for the written exam question related to big data in health, the percentage of students receiving maximum points in the rest of the exam questions ranged from 20% to 90% with an average of 56%.

I INTRODUCTION

When studying to achieve a master's degree, it becomes imperative for students to be able to read, understand and explain scientific texts within their chosen field of study. Understanding the scientific methods, as well as their possible applications and limitations is a fundamental academic skill, which may support students' critical reflection whether they will later pursue a career in industry or in academia. However, we experience that our engineering students read scientific articles, as if they were text books and focus on recall rather than understanding and reflection. In addition, they tend to only read scientific articles when it is absolutely necessary and demanded from the lecturer. Consequently, we have developed a method with the aim to support engineering students in understanding scientific articles. We developed our method taking into account the reading practice of experts, well-known strategies for learning from text, and student's preferences for problem solving activities. We refer to our method as Detective work, and we explain the background in the following paragraph, and the actual method in section II and III.

Scientific texts and how they are read

Developing methods for improving student's abilities to read scientific text require a basic understanding of what a scientific text is, how it is written and how experts read scientific texts compared to novices.

Geisler gives a thorough introduction into these aspects (Geisler 2013). She explains that the scientific article has often been viewed as an autonomous text i.e. a text written with a specific intention, which is expected to be understood similarly by all readers. However, research has shown that scientific articles are rhetorical constructs where the writer wants you to follow his or her line of argument. When reading, faculty members will tend to resist the line of argument, engage in finding contextual details, assess claims and pay attention to methodological details that they from experience know will affect the result. In contrast students will tend to try to follow the line of argument and end up agreeing with the authors (Geisler 2013). One aim of our method was to help students use a reading strategies of experts rather than novices.

Students learning strategies when reading scientific texts

Supporting students in comprehension rather than recall is important because we want to support learning strategies associated with deep leaning rather than surface learning (Marton, Säljö 1976). A comprehensive review of learning techniques, not specifically related to higher education, have shown that different strategies exists such as elaborative interrogation, self-explanation, summarization, keyword mnemonic and practise testing. Overall findings suggest that students who possess abilities such as elaborative interrogation and self-explanation generally perform better than students with other simple learning strategies such as summarization and keyword mnemonic, but they also show that students with strategies that relate theory to practise performs better than all the simple methods (Dunlosky et al. 2013). Findings are consistent with Aalborg University's PBL strategy where the principle of relating theory to practice is a corner stone. In our experience, the motivation for reading a scientific article (whether it is in a course or is related to projects work) is that the knowledge you gain from one text can be incorporated with the students a priori knowledge, so that they understand the overall problem or solution in a new way or even better than they did, before they read the text. However, a new study shows that student's arguments are only rarely based on more than one text (Linderholm et al. 2014), and from our current practice we recognize students' problems of forming an argument based on more than one text. In particular, this is a problem for new master students that moves from primarily reading textbooks to primarily reading scientific articles because they have to learn to navigate within a set of scientific perspectives from different authors that might be aligned or contradicting, rather than being presented with a textbook and presume that it is presenting the truth. Consequently, we had to keep in mind that even though our aim was to teach students to read and understand one academic text better, we also wanted them to be able to put the text into the context of what they knew beforehand, and what they had been reading before, - they had to understand and relate.

Learning preferences of engineering students

Engineering students often have a learning preference for active learning rather than reflective learning (Felder, Silverman 1988), and it is well-known from our teaching practise that reading scientific texts or listening to lecturers about research does not come natural to most of our students. Consequently, we aimed at developing a method to make scientific reading a problem solving activity to fit the learning style of most of the engineering students. In the following section, we explain how we applied the above mentioned principles to design the detective work method.

II GENERAL METHOD: DETECTIVE WORK TO SUPPORT COMPREHENSION OF SCIENTIFIC ARTICLES

In detective work, questions concerning a specific scientific text are formulated by the lecturer. The questions are characterized by not requiring an overview of the text beforehand because they should support a non-sequential reading activity, and not having understanding as a prerequisite. This is where the term "detective work" originated i.e. the students are asked to collect separate pieces of evidence by answering the questions, and after having collected all the evidence, they may see the full picture. In the following we explain how our detective works are designed to take into account the reading practice of experts, well-known strategies for learning from text, and student's preferences for problem solving activities.

Reading practice of experts

In our detective work, we specifically tell the students not to read the text before the lecture because we want to prevent that they read sequentially, and understand the content of the article as a given truth. We use questions to support a non-sequential reading activity and to direct the students to methodological details.

Application of known learning strategies

The questions are characterized by either relating to student's prior knowledge or being explanatory. Questions that relate to prior knowledge support students in comprehending one scientific text in the context of other scientific texts. Explanatory questions are aimed at supporting students in self-explaining while reading. In addition, discussing the answers with the students in a small group, with the rest of the class and with the lecturer further support the approach of "learning by explaining".

Problem solving

When reading a text, the aim is that students add the new reading to their existing knowledge. In its core, this is not problem solving even though the extra knowledge might help them in solving problems later on in the course or as a part of project work. However, the different activities in the detective work incorporate elements of problem solving, team work and competition to motivate students to work actively with the scientific article. The activities of detective work is:

1. Written and oral introduction to the assignment
2. Groups of 2-3 students are formed
3. Each group choose one question from a common detective work question sheet – groups cannot choose the same question
4. Groups answer questions and send a few slides to the lecturer to document the answer
5. Each group choose a new question from the question sheet. Point 3-5 are repeated until all questions are answered, or time runs out
6. The groups present their answers to the whole class, receive feedback from the lecturer, and get access to the whole set of slides afterwards.

The written introduction, which is instructive and detailed in explanation style, and includes the whole set of detective work questions, supports the idea of having a task that the students have to solve together, and that the students, who work fastest will get the opportunity of choosing questions first. In the following section, we explain a specific design of detective work for a course in "Methods and Models for Clinical Information Systems"

III SPECIFIC METHOD: DETECTIVE WORK USED IN A MEDICAL INFORMATICS COURSE

We have developed a detective work session for the course, Method and Models Clinical information systems, which is placed as an elective course in the second semester of Aalborg University's master programme in Biomedical Engineering and Informatics. The detective work sessions were designed and used initially in the spring semester 2014, and based on these experiences two detective work sessions, one about big data and one about NoSql databases have been updated, carried out and evaluated in the spring semester 2015. This section take its point of departure in the detective work session about big data, because this session is mostly balanced towards students comprehending the content of one scientific article, whereas the NoSQL session is placed at a subsequent time in the course, and consequently, focuses more on relating the scientific article to knowledge achieved by the students earlier in the course. Whereas both is within the aim of the detective work, the first is more illustrative for people outside the field of clinical information systems research because it does not presume very much a priori knowledge.

Type of questions

The detective work example is based on a scientific article where big data for health care applications is introduced (Jensen et al. 2012), and we have included the whole detective work description in the appendix. The set of questions include nine questions. Three of these questions (3,4,5) are concerned with explaining figures in the scientific article. When students explain figures to each other, they start comprehending some of the basic ideas of the article. Other questions (1,7,8,9) follow up on this direction by letting the students explain different aspects of the paper, and answer "what" and "how" questions. In addition, two of these questions (1, 3) that focus on explanations, are also relating the scientific article to students' a priori knowledge, and one question (5) asks about a professional opinion. These add-ons to some of the questions are designed to support reflection on the relation to the rest of the course. The last two questions (2,6) are asking "why", and they are directing the students towards considering some of the methodological challenges of big data in health.

Simplicity as a guiding principle

Many of the questions have page numbers or figure numbers attached because we did not want the students to focus on "locating the right place", and we could not presume that they had an overview of the text because they were instructed not to read it beforehand. Often, when lecturers design questions they are defined as quiz or exam questions, meant to evaluate the intended learning outcomes. In contrast, these detective work questions are designed to be simple, and most answers can be found by the students directly in the text. We aimed to design a process that allowed the students to learn from the text, and that required simplicity and close-to-the-text questions.

IV EVALUATION OF DETECTIVE WORK USED IN MEDICAL INFORMATICS

When doing the detective work, we observed that students became engaged in discussing the article in small groups, and they were able to complete the detective work questions. Only one question was not answered due to lack of time. However, explaining close-to-text questions seemed easier than explaining questions that related to prior knowledge and "why" questions. The slides produced by the students (1-2 per question) had a lot of text on them, and were more directed towards remembering the content of the scientific article, than presenting the content for others. At the presentation, feedback was given by the lecturer to correct mistakes, supplement with details, and direct the students toward the answer of the question that was not answered.

At the time where we evaluated the course "Method and Models Clinical information systems", student feedback suggested, that the students were concerned with the fact that they had gained knowledge concerning the set of questions that they worked with during the detective work session in small groups, but the knowledge concerning the questions that the other students worked with and presented, they learned much more superficial. In addition, they did not know how to prepare for their exam because they did not know the depth of knowledge, which they were expected to have learned i.e. they experienced a mix of surface and deep learning. Consequently, some students would prefer the classic approach where the whole text presented by a lecturer to support them in sense-making. In addition, some students expressed insecurity about the session where the answers to the questions was presented. They did not like to present material, which they were not one hundred percent sure of was correct. Exam results showed that 80% of students received maximum points for the written exam question related to big data in health, which was the topic of the detective work. The percentage of students receiving maximum points in the rest of the exam questions ranged from 20% to 90% with an average of 56%.

V DISCUSSION

When we used the detective work method in our medical informatics course, the students worked actively in small groups with a scientific article, and the detective work questions helped them extract core points from that article, and to present the points to the class. Student feedback was mixed, but exam scores were satisfactory.

Some students seemed to prefer the method that they were used to with lectures followed by quiz/group work. In classic lectures, a well-planned line of argument is presented by the lecturer, which sometimes make the content look easier than it actually is, and tends not to take into account too many contradictions. After lectures, students may feel that they have obtained a nice overview, and know the depth of knowledge, that they are expected to live up to at the exam. However, the students are put into a passive position in this process, and are most likely not to be engaged in explaining the content, or in reflecting critically on the line of argument of the lecture. In this study, we were actually pleased that the students experienced mixture of surface and deep learning. Now, we just need the students to perceive these experiences into something positive. In the future, we will make sure that students are instructed on how to reach a consistent deep learning level, by doing additional work after class e.g. an e-learning follow-up approach with a wiki-page where each question can be answered by the students to support the formation of a learning community. Building a learning community by using online tools, has earlier been suggested as a blended learning approach (Bell 2014). This approach would also solve the timing issue, because no more than one lecture can be spent on big data in health, and many of the other presented topics. We do not plan on making modifications based on the students' reported insecurity related to presenting new material. Striving for perfection in presentation will take up too much time compared to the learning outcome. We further believe that an imperfect presentation is a good additional skill to learn. For example, knowledge sharing activities may benefit from staff that can work with a text efficiently, and present what they have learned without overspending the allocated time resources.

We have suggested the detective work as a method to support students when reading scientific papers, both to help them comprehend the content of the scientific article, but also to illustrate a method that can be used when reading other scientific articles. Learning about and getting experience with the science of a profession have been the focus of previous studies, and they range from classic lecture based approaches where students are taught to read and write science (Marušic, Marušic 2003), to e-learning approaches that seek to harmonize how science can be taught (Kulier et al. 2008). However, these are dedicated courses, whereas higher educations have the goal of research based teaching as a part of all education and courses. To make research based teaching more than a vision, we have to enhance the science literacy among students. Science literacy is one of the focus areas of the detective work method, and it has also been subject to earlier research (Levine 2001). Whereas Levine's approach differs from ours in that students home work are centred around getting an overview of the text and answering one dedicated question, both methods have elements of group work and contextual reflection, and succeed in making students work actively with a given text. One limitation of our study is that we have not been able to measure whether we improved the general science literacy through our method, because we did not evaluate whether the detective work made the students read other scientific articles within the field of medical informatics differently. However, the instructive nature of the detective work might be counter-effective in the respect of re-using the approach when reading other texts with because questions are dedicated to this one study. More general questions or tasks where the students have to formulate questions as well as answers might help improve the general science literacy among students, but may be too complex to be feasible.

VI CONCLUSIONS

In this study, we designed a method to support students when reading scientific papers that build on the principles of:

1. Non-sequential reading to use the reading practise of experts
2. Learning by explaining and contextualizing
3. Enhance motivation by using elements of problem solving, team work and competition

We applied the principles in a detective work session about big data in health, and evaluated it by observing the students work, listen to students feedback, and through the written exam. The students' feedback was mixed, but engagement in coursework and exam results suggested that the detective work supported students in reading a scientific article, and comprehending its content. Reflections on whether students use the detective work as a guide to how other scientific articles can be read and comprehended, have not been evaluated as part of this study.

VII ACKNOWLEDGEMENTS

We would like to acknowledge Pia Britt Elberg for reviewing the detective work questions and work sheets before they were given to the class.

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IX APPENDIX: DETECTIVE WORK RELATED TO BIG DATA FOR HEALTH CARE APPLICATIONS

Mining electronic health records: towards better research applications and clinical care. Peter B. Jensen, Lars J. Jensen and Søren Brunak.

In your groups, choose one of the questions marked with (I) and answer it. Document your answer as one or two power point slides and send it to kirse@hst.aau.dk, name the presentation with the number of the question (3-5). All groups should answer different questions.
When you are done choose a question of type (II), document it in a similar manner, name it (1,2,6-9) and send it.
When all questions are answered, a power point presentation will be assembled -- hopefully covering all the important aspects of today's text ;-)
Finally, the groups will present the slides they have created in the following order:

1. What are the potentials of data mining in health care? (General answer and at least one clinical example of your own making) (II)
2. Why does use of administrative data introduce biases? And why are administrative data sources utilized for research purposes anyway?(II)
3. Explain figure 1 in your own words. How is the figure simplified compared to the actual heterogeneity of Electronic health record content? (I)
4. What characterises clinical text? Clinical text is a challenge in a mining perspective. NLP and standardised terminology might be a solution, explain how (include an explanation of BOX 1). (I)
5. Explain figure 2. In your professional opinion, which way of analysing EHR-data holds the greatest promise? (I)
6. Why should you be aware of transitive relationships when exploring correlations?(II)
7. What is a cohort study? And how can mining approaches assist these studies?(II)
8. What are the potentials and challenges of linking EHR data and genetic data?(II)
9. Name and explain the limiting factors. See p. 402-403 (II)

X BIOGRAPHICAL INFORMATION

Kirstine Rosenbeck Gøeg just received her PhD-degree, and she is now employed as a scientific assistant at the Department of Health science and Technology, Aalborg University, Denmark. Her main area of research is terminologies and information models in clinical information systems. Among other teaching related tasks, she introduces students to the methodologies applied in medical research and clinical information system research.

Lone Krogh is an associate professor and head of Higher Education Research Group at the Department of Learning and Philosophy. Her main area of research is ensuring the quality of higher education e.g. by focusing on assessment methods at university level. Her teaching is mostly directed towards "teaching the teachers" e.g. at the assistant professors' pedagogy courses at Aalborg University.

Abstracts/Papers
Active Poster Session

Active learning in Engineering Educations– also for special needs students

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ABSTRACT

Keywords – Special needs, active learning, large classes.

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

Background

Active learning focuses on students doing activities and thinking about the activities they are doing (Bonwell and Eison, 1991). Key elements of this are to question and explore a topic. This is often done as a group activity.
Statistically, engineering educations have attracted students with special needs particularally within the autism spectrum. This is often due to the fascination with repetitions and numbers that people on this spectrum often have. Students with these kinds of special needs taking University classes are often challenged in two main ways by this approach:

a. The idea to challenge or debate an issue can often make these students feel uncertain as they don't know what the "right" answer is; what they are supposed to come up with.
b. Working in groups, or doing any group activities, can make these students feel uncertain as humans, unlike numbers, can seem unpredictable and uncontrollable.

In this poster I would like to encourage a debate regarding how we can create the most learning environment not only for regular students but also for students with special needs.

Explanation and set-up

It is important when teaching large classes that an active learning environment is created for both regular students and students with special needs. This is not something that will happen on its own and it is an element of teaching at University level which is often overlooked. However, to do this the teacher needs the tools and resources to pay special attention to these students, without losing overview of the learning progress for the regular students.

Results

From my teaching I have found there are four main elements essential to balance ensuring an active learning environment for regular students and ensuring a safe and stimulating environment for special needs students:

1. Education for teachers regarding the different needs that different special need students can have. It is vital that teachers feel they are properly prepared for this challenge and that they realize that every special needs student is different.
2. Talk to the special needs students. Find out what they feel they can cope with and what they feel is too much. Acknowledge their limitations but don't hold them back
3. If doing group activities it can be a good idea to explain to the regular students the needs of the special needs student; after agreement with the special needs student.

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PBL – Reflections after 10 years

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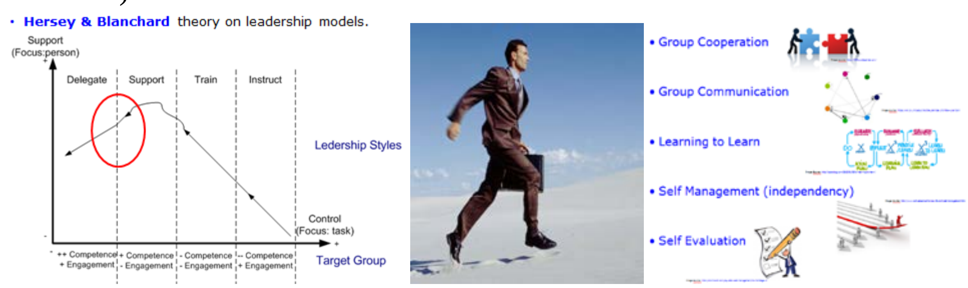
ABSTRACT

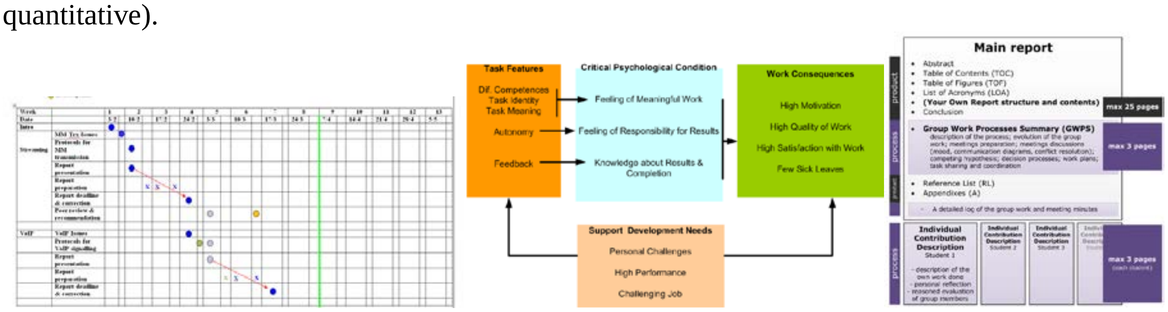
Keywords – PBL, alignment, soft competences

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

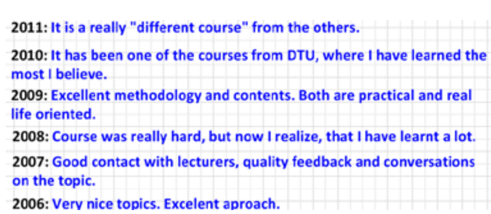
The poster describes course 34357 at DTU, where PBL has been used in the last 10 years. While the course responsibles where not aware initially that the used methodology was PBL, the poster describes the triggering idea for the initial taken choices, i.e. *homogenize working methodologies for students with different backgrounds (technical, cultural, personal) and prepare them to work independently towards their incipient arrival to the job market*, within the context of an specific engineering realm (Telecommunications).



The poster will then explain how the course is setup: i.e. as a *role game*, where students take the role of consulting teams, working for an industrial customer, and *planned*: sequence of tasks, tasks increasing progressive evolution, *student dialog-based support*, *assessment* (process vs product, qualitative vs quantitative).



The poster will try to describe as well *student evolution* during the duration of the course, based on previous statistical data collection as well as based on qualitative feedback gathered after each session during the last 10 years.



Active learning about research methodology and theory of science in engineering education

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ABSTRACT

Keywords – active learning, research methodology, theory of science

INTRODUCTION

Rationale

Research methodology and theory of science have become important teaching subjects en engineering education as well as in higher education in general (Silver, 2013). This is rooted in the transition to a knowledge society. Today, it is argued by many that we are well on the way to an era beyond modernity and the sort of industrial economy that came with it. Whatever else the new era brings – the globalization of risks, environmental problems, new technologies, etc. – knowledge and the ability to seek, produce, apply and transform knowledge is of huge importance (Hargreaves, 2003).
However, research methodology and theory of science if often not favored subjects by engineering students, who tend to find the subjects abstract. Thus, the students are often very engaged in the subjects, nor are textbooks or teaching very engaging.
This poster asks how we can promote active learning in research methodology and theory of science?
Based on a pragmatic reading of Batesons logical categories of learning, the poster suggests a conceptual framework for competence development in research methodology and theory of science, which identify different sets of competencies (instrumental, practical, analytical and critical) as well as learning activities to promote them.

Expected outcome

I will suggest a conceptual framework for competence development in research methodology and theory of science, which identify different sets of competencies (instrumental, practical, analytical and critical) as well as learning activities to promote them.

Session type: Poster

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Turning to adaption through exploration in the education of Software Engineering

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ABSTRACT
This paper aims to emphasize the importance of an activating teaching staff in the context of higher education. The presented application of Online learning journals in the domain of software engineering pursues this intention.
On the one hand, the method of a lecture accompanying Online learning diary is used for the individual and honest reflection of students and lecturers, on the other hand, it shall identify their status quo during the learning process. In order to use the resources of this instrument to its fullest extend, the role of the lecturer in the process of teaching and learning is elaborated in detail. The first section (contextual conditions) describes the application of Online learning journals in parallel with the lecture of Software Engineering at the OTH Regensburg. Especially the activating function of the instrument within students and lecturers during the semester is elaborated. The subsequent part of this paper discusses the difference of feedback and reflection (Feedback and Reflection - a short excursion) and how these two processes involve with the model presented, how they built on one another and how their implementation. In the third part (process structure / acquisition and evaluation procedures) the lecturer's key role in the process of reflection, after termination of the term, is explained. Group discussion as a method of qualitative research and its application in the case presented is essential. Results of the qualitative explorative research method are content of the fourth part of this paper (results of research). How those results might contribute to improve the processes of teaching and learning and what changes consequently arise, is finally addressed in the chapter “Outlook”.

Keywords - Feedback/Reflection model; Online learning journal; Group discussion; Software Engineering

I CONTEXTUAL CONDITIONS

Implicit assumption of teaching in higher education is the teacher's function -especially in a theoretical and research-based scientific study path- to create his teaching in an activating manner and to activate students (cf. Bachmann 2013, p.11et seq.). Students are - unlike in times when they were referred to as "listeners"- expected to actively elaborate and acquire content. Both expectations require to reconsider the teaching-learning situation per se as well as in relation to the presentation of content and the process of teaching and learning.

The ability to reflect one's own learning processes and in conclusion to take responsibility for the own teaching and learning processes, cannot be "assumed a priori" (see Hilzensauer 2009, p.1) - neither for students nor for lecturers. This interaction is the reason to examine a one-semester teaching experiment with the following research question:
“How does teaching staff become active and provides support for students to become active with regard to their learning behaviour?”
As research method the "Online learning journal" was applied.

The experiment, aiming to approach the meta-goal of teachers taking over responsibility and activating students using an own internal impulse, is based on a systematic feedback and reflection model (s. Figure 3; it will be focused later on). By using the lecture accompanying Online learning journal within the lecture Software Engineering, lecturer[1] as well as learner is actively involved in a recursive learning process. Every week the lecturer´s devolop questions in order to rework the content on the online platform (www.oltb.de[2]) for the students. We subdivided three categories:

Table 1: Question categories in the Online learning Journal

Category I	Technical contents are focused - Aim: Repetition
Category II	Tasks/questions with focus on writing skills
Category III	Questions serving the self-reflection of learning behavior

The time limit to work on the questions is five days. This period is followed by three days of individual examination of the student's answers. In addition, one PhD and the student assistant analyze the answers. Collective or individual knowledge gaps can be identified within a team discussion, in which all team members are taking part, concerning category I-III. In the subsequent lecture, identified knowledge gaps or difficulties are discussed with the students.

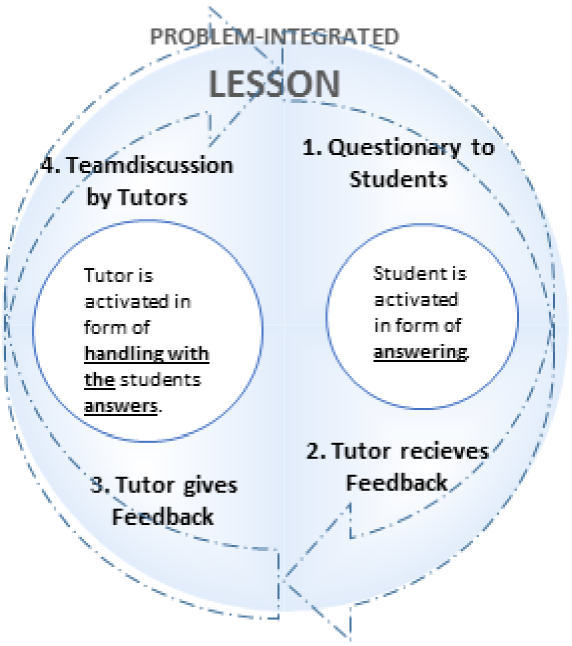

Figure 1: "Week-wheel"- Period of a Week out of the "Activation-View"

Figure 1 illustrates the weekly cycle (week-wheel) of activation: The Online learning journal gives students the opportunity of individual reworking of learning objectives immediately after the lecture and thus takes on an activating function for the students. Aim is the consolidation of knowledge and the reflection of own learning behavior (cf. Trautwein 2013, S. 118et seq.). The lecturer's feedback on the student's online responses provides- besides the selection of teaching content in advance of the lecture- a first activity of the teaching staff part. As lecturers analyze the student's online responses, the opportunity arises to identify for instance recognizable knowledge and understanding gaps out of the current course context and subsequently to process as well as to settle those in the following event (= problem-integrated lesson). The process of reciprocal feedback for state of knowledge and reflection (the differentiated use of feedback and reflection is explained within the following chapter) is repeated on a weekly basis during the semester. The lecture Software Engineering is literally "inter-active". Within this section

[1] In our case the lecturer/teaching staff consists of one Professor, three PhD´s and one master student.

[2] www.oltb.de is a german open source online platform. This medium supports teaching-learning processes with different features like for example to commentate and purpose continuing learning developments, the comparison of own learning processes and so on.

(Figure 1) the activating function of Online learning journal is described with regard to one lecture. Figure 3 in contrast, illustrates the role of a whole lecture unit in the overall construct of feedback and reflection of one semester. In order to address group discussion, the focused research tool of this paper and the terms of feedback and reflection are defined within the following chapter.

II FEEDBACK AND REFLECTION - A SHORT EXCURSION

In academic literature, the terms feedback and reflection are often used interchangeably and are not clearly defined. In order to answer the research question, a short explication of underlying terms is indispensable.

Feedback

To clarify the comprehension of feedback, the case of the application "week wheel" of Figure 1 is addressed. The explanation of feedback can be derived from this description. In the present case, feedback takes place between two groups: students on the one hand and lecturers on the other. Apparent from Figure 2, two dimensions are addressed by Feedback:

Dimension 1 "give feedback"; Dimension 2 "receive feedback". In the case of application of the "Online learning journal" the student's question answering (=activity) is followed by the lecturer's receiving of feedback (=received feedback) and causes a corresponding statement (=response/ giving Feedback) by the lecturers.[3] Feedback is considered in terms of response.

One person's reaction causes a statement, for instance a clarifying explanation (cf. Stangl 2012) or a behavior in another person. Here a distinction is made between "giving feedback" and "receiving feedback"

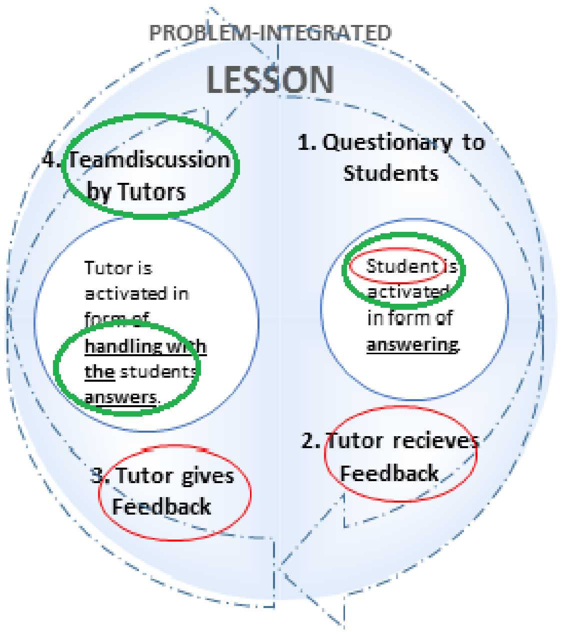

Figure 2: Situations of the weekly Feedback (red-marked); Situations of a weekly Reflection (green-marked)

Reflection

In contrast to feedback, the concept of reflection is discussed from multiple perspectives. Derived from the Latin the verb "reflektere" it means reflect. Moon applies the term to the process of learning. According to her, professional reflecting is directed towards a learning process, but conversely, not every learning process is necessarily reflexive (cf. Moon 2004, p. 83). This statement describes reflection as a tool in the process of learning. One interpretation is that a further development should be aimed by using reflection in the context of learning. Wyss refers the process of reflection to conscious considering and thinking, which can appear before, during or after a situation or action (cf. Wyss 2009, p. 5). Muehlhausen extends the description to aspects of analysis and reflection, which results in

[3] The feedback lecturers receive is usually located in the question categories II + III, which also addresses learning place and learning environment

dividing the reflection process in two separate processes (cf. ibid. p. 6). Further differentiations of the reflection process could be given, but would not be relevant to the present examination and are therefore not included (see the essays of Hilzenauer and Wyss 2008). As definition of reflection should be noted, that reflection:

- Is purposeful;
- Is conscious reflecting and analyzing before, during or after a certain situation or action in processes of teaching and learning and/or education;
- Is taking place mentally or in written form;
- Can be distinguished between self- and external-reflection (see Wyss 2008, p.3);
- Can be related to further dimensions such as reflecting on learning subject, learning activity or ability to learn (see Hilzensauer 2008, p. 9);
- Can proceed process-like (on levels of description; analysis/interpretation, evaluation; planning) (see Bräuer 2014, p. 27);
- Can take place on different levels (meta-, meso-, micro-level) (see Wyss 2008 6f.).

Figure 2 shows to which extend processes of reflection are aimed during a week of lectures. [4] Specific questions aim to stimulate the reflection processes referring to learning subject (category I), learning activity and learning ability (category III) within the students. An example is: *"Which contents of today's lecture appear still unclear? Why do you need this content and how can you fill this knowledge gap?"*
These questions are associated to self-reflection, because students enter into a dialogue with themselves while thinking (cf. Kroath 2004, p. 84). Students are encouraged to identify their personal learning difficulties and content gaps while acting self-critically (cf. Siebert, quoted according to Hilzensauer, 2008, p. 7). Furthermore the lecturer's reflection processes are set in motion. As the lecturer is confronted with existing student feedback, self reflection is triggered. Questions posed by the lecturer are: "*Do the answers fit my pre-formulated learning goals? Are the answers technically correct? What contents have repeatedly been mentioned as not understood? What kind of personal/emotional context factors could have an impact on student's as well as lecturers answers?"*
In the discourse of teacher teams, the possibility of peer-reflection (see. Wyss 2008, p. 7), based on findings of previous self-reflection, arises. As a result, the following lecture can be adapted based on the results of peer-reflection.

Interaction of Feedback and Reflection

In summary it can be stated, that feedback can be given active and/or received more passively. The receiver initially doesn't need to induce any further actions. At least two people are involved in the process of feedback. Reflection in contrast fulfills a more extensive task: It is virtually an act that can take place even in a single person and - when used systematically- pursues focussed objectives. Feedback therefore can be seen as kind of "pre-function", which reveals potential for change and can lead to a systematic reflection. Thus it can be considered as valuable part of reflection. In the presented context, the commonality of both concepts can be described by their superior function as methods to raise awareness of personal actions/attitudes and to launch learning processes. When applied in combination, both thought and speech processes aim for the further development of teaching and learning processes. The model of systematic feedback and reflection presented in part III takes up the idea of upstream and integrated feedback. It controls the reflection process within and even more after the lecture (see. Bastian / Combe / Langer 2007, p. 11).

[4] The reflection process will be elaborated more detailed in the third part of this paper, because focus of this part is the activation of lecturer staff, which takes place after the lecture period.

III PROCESS STRUCTURE / SURVEY PROCEDURE AND EVALUATION

The quality of purposeful reflection is significantly depending on structure and methods of the reflection process (see Bräuer 2006, p. 346). Therefore the process structure of the applied systematic feedback and reflection model is revealed at the beginning of section III (Figure 3).

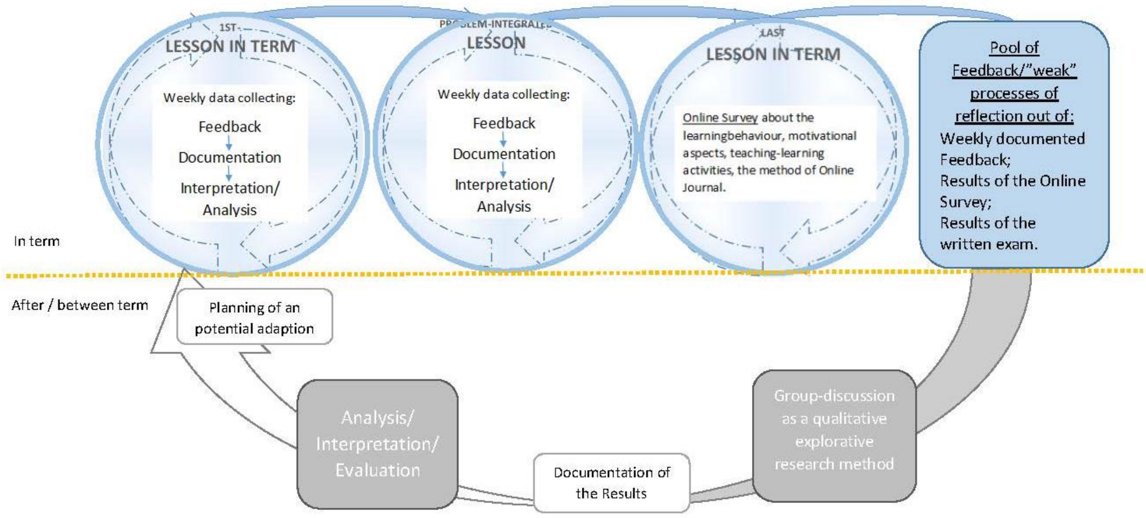

Figure 3: Systematic Feedback-Reflection model

Process structure

The area above the yellow line summarizes the feedback and reflection processes during a semester lecture cycle. After each lecture the students are asked questions, their answers are documented, interpreted and analyzed. Identified knowledge gaps and emotional statements are discussed in the next lecture unit. This process is repeated throughout the semester. In the last lecture unit, students complete an online survey concerning learning behavior, motivational aspects, teaching-learning activities and the instrument "Online learning journal". Thus a pool of feedback and "weak" reflection processes is generated out of different sources. According to Bräuer (2014, p. 29) reflexive evaluation is situated on various levels. The reflection during the semester is located on level 2 out of four possible levels. The process of activities (in this case the answers and abnormalities gathered with the Online learning journal) is *documented (level 1*) and *circumstances of those activities are analyzed and interpreted (level 2)*. The lecturers receive comprehensive explanations about circumstances during student learning activities (see Table 1 in. Bräuer, 2014, p. 29). As the student answers concerning learning contents shall be given well-founded, specific causes can be derived. Measured on Bräuer's levels of reflection (cf. Bräuer, 2014, p. 29) those two reflection processes can be assigned to the basic levels.

In order to achieve the prime goal of the reflection process described, namely the activation of student learning behavior due to their lecturer's activities, another source of knowledge is necessary.

Survey and reflection measures concerning level 3 and 4 of the reflection process

The still "weak" reflection processes of teachers (=activity of lecturer staff) can trigger development processes within students, for instance when activating their own learning

behavior. An example is the acquisition of knowledge in addition to the lecture with the help of the Online learning Journal. However, these adjustments are mainly confined to technical and content areas. Likewise the reflection taken place so far only takes place in a regular cycle of one semester. So far, the student's feedback concerning content structure or selectively addressed self-reflective questions, does not give any further insight into the student's experiences with the Online learning journal and its impact on learning behavior. The Student's emotions, attitudes and opinions concerning conditions (amount of time, communication between teachers and learners, methodology, etc.) are not taken into account sufficiently in the previous process of reflection. So far, the teachers view on students dominates their behavior during the semester. This "image of students" shall be expanded due to the dialog via online survey. The gathered information is indispensable for an "adaptive learning process" as it is assumed, that students experience the teaching-learning process different than lecturers (see. Bastian/Combe/Langer 2007, p. 13). Insights concerning emotions, attitudes and opinions regarding the learning context, communication between teachers and learners, the methods and the provision of performance evidence (written exam at the end of the semester), have not been considered enough during the semester. The third of the levels defined by Bräuer (Level 3: A completed activity is be evaluated) (cf. 2014, p. 29) is obtained when results of the online survey are evaluated. Conspicuous multiple responses to open questions of the survey, which arose as disincentive to self-learning behavior were noted. The results are presented in part IV.
Also lecturers are involved in the process of feedback and reflection and evaluated concerning their teaching-learning activities after the lecture period. According to Bräuer, they should undergo the third phase of the reflection process like students do.
The survey measure for teachers is a qualitative-explorative method, the group discussion. It is a form of self-reflection, which is closely linked to the research subject. Methodology and research subject therefore influence each other reciprocally (Loos/Schäffer 2001).
The decision for this survey method results from the consideration, that information which could not be gathered by a quantitative measure, is exchanged during a conversation. A group dialog can generate new insights. Core of the dialogue are actions and interactions with persons (in this case with students/colleagues) that take place within the framework of the Online learning journal and the lecture Software Engineering. Through impulses of a moderator, the research subject is kept in focus. The basic incentives of group discussion pursue evaluative moments, such as the emotions, attitudes and opinions of the lecturers concerning basic conditions and students during the semester. Examples of question impulses are: *"How does the Online learning journal impact your point of view on the students? Did it change? How important was the structure of question categories?"* Towards the end of the discussion, the compound of Online learning journal with the supply module Software Engineering was brought to bear:"*...so does the Online learning journal fit to Software Engineering?"* Only a couple of question impulses from an one-hour discussion, which became kind of independent and exceeded the scheduled duration, were mentioned.
The systematical and structured evaluation of the group discussion is based on the qualitative content analysis of Mayring (2010). The group discussion transcript is structured, in order to filter different aspects of the data material. The categories/criteria described in table 1 serve as base (see. Mayring 2010, p. 65). Structure dimensions, which can be subdivided in teaching and learning promoting (D1) or inhibiting (D2) factors that may influence the teaching and learning activity, can be derived from the research question. The following categories are explicitly defined, to which the textual elements of the group discussion are associated with:

Table 2: System of Categories following the qualitative content analysis

Category	Definition
1) Student's registered feedback for teaching staff	Feedback from students for teaching staff: the parties involved inform themselves about their different point of views and their mental state. The written and oral dialogue between students and teachers promotes the teaching and learning activity.
2) Reflection within the team (Online learning J. – Students)	Exchange among lecturers: That means students action within the Online learning journal are reflected based on feedback from the students in terms of reflection with the possibility of further development
3) Attitude of lecturers	Attitude with respect to students: The awareness of the term "student" is expressed. It becomes evident how lecturers perceive students.
4) Expectations	Expectations towards students in the context of higher education: It is expressed what expectations lecturers have towards students. The expectations relate to the higher education.
5) Potential Online learning journal (as method)	The Online learning journal as a medium to support teaching and learning: the Online learning journal supports a teaching and learning environment, which intends to activate students/lecturers.

Structuring the content into different categories offers the possibility to extract focused topics, contents and aspects out of the gathered material. The results are discussed in section IV. As the evaluation of results shows, different categories are mutually dependent. The text passages allocated to the categories refer to each other and are considered to be independent; in the overall context they cannot be considered selective.

IV RESEARCH RESULTS

Subsequently the results of the online survey and the group discussion are contrasted within the dimensions D1 and D2. This seems reasonable, because the research question is addressing teaching and learning promoting (activating) as well as teaching and learning inhibiting (deactivating) aspects of Online learning journals in the lecture of software engineering. The results of the online survey are explained form the learner's perspective, while the results of the group discussion represent the lecturer's point of view.

Table 3: Summary of the research Results

Dimension	**Perspective**
	Teacher's perspective
D1) Teaching/ Learning promoting/ activating aspects	- Motivation is given due to participation of students at the Online learning journal - Personal contact with students is promoted - Further development of the method Online learning journal during use reduced distance to students - Different knowledge levels of students became clear → an individual reaction to the students different states of knowledge becomes possible - Gain of respect - Students are not assessed

	- Transparency ▶ **Teachers provide security and confidence**	
	Student's perspective	Teacher's perspective
D1) Teaching/ Learning promoting/ activating aspects	- Assessment of individual knowledge gaps - Receiving individual feedback - Continuity and regularity of processing - Distribution of learning volume Exam preparation - Intercepting effect on not adequately mediated teaching contents - Course accompanying worksheets - Trust and confidence promoting platform - Requirements are more comprehensible ▶ **Students search for/need security and trust**	- Diversity among students can be addressed - Individual feedback is possible - Flexible structure of the Online Journal is important ▶ **Individual support/diversity/ flexibility**
	Teacher's perspective	
D2) Teaching/ Learning inhibiting/ deactivating aspects	- Unmotivated, faltering answers - Full potential of the methodology cannot be used due to lack of time - Learners are considered to be dependent ▶ **time aspect / expectations and attitudes towards learners limit the capacity to act.**	
	Student's perspective	
D2) Teaching/ Learning inhibiting/ deactivating aspects	- High expenditure of time - Poor feedback to the lecture - Partly unfriendly communication via Online learning journal - Comparison with student's worksheets (too much aid?) ▶ **pressure and lack of / poor communication among the teaching staff**	

<u>Dimension 1) Teaching and learning promoting, thus activating aspects</u>

Security, trust and learning promoting conditions are considered to be important key aspects when dealing with learners. The results of the group discussion confirm, that based on personal contact, which arises due to the Online learning journal (for instance by email after the lectures), confidence is built and a motivating working relationship is formed. The learning and the teaching activity is stimulated. The feedback received promotes security within learners and teachers. This security is reflected in their actions. Trust includes respectful behavior towards teachers and learners, thus a transparent feedback becomes possible.

Individual student support, the option to consider **different knowledge and need levels** of the students as well as the **flexibility** and adaptability within the questions asked, are further learning promoting aspects. Through the Online learning journal teachers old patterns and ways of thinking of the teacher can be disrupted. The Teacher becomes aware of their traditional and own logics concerning teaching content. A better understanding of the learner's logic, confronted with the teaching content for the first time, is provided through the feedback in the Online learning journal. The flexibility of being able to respond individually to develop adapted questions and respond indivitiually to given answers, is a learning promoting aspect with high added value.

<u>Dimension 2) Teaching and learning inhibiting, thus deactivating aspects</u>

The **exertion of pressure** and **lacking or poor communication** (within lecturers staff or between lecturer and learner) are central facts in teaching and learning inhibiting categories. The teaching staff shares certain **expectations and attitudes** towards the students. The learners mention in the online survey feeling a certain pressure. When the Online learning journal was initially implemented at the OTH Regensburg in software engineering, the lecturer had certain pre-expectations towards the students. Students were often assumed in

the role of pupils. Words like "lazy" or "lack of motivation" were mentioned. These attitudes, formulated admittedly exaggerated, probably have an -unconscious- influence on the lecturers teaching behavior.
Furthermore the factor **time** is a learning and teaching inhibiting factor. The processing time of the Online learning journal, which was supposed to be half an hour at the beginning of the semester, was exceeded regularly. The extra amount of time students had to invest inhibited their motivation. In retrospective the extra amount of time was demotivating for teachers as well. Questions were answered minimally. The lecturer staff reduced commitment to provide value-adding questions. The mentioned inhibiting factors affected the teacher's capacity to act and had a demotivating impact.

V OUTLOOK

The consequence of this intermeshed evaluation is to plan new strategies for action. The fourth level *(Level 4: As a consequence of a completed activity new activities and strategies are planned)* of a reflective practice by Bräuer (see Bräuer 2014 p.29) is elaborated in the last part. The plan accompanying question may be summed up as follows: "How can the student's self-learn activity be promoted realistically within the next semester, based on the obtained categories (see Table 2)?"
It has to be anticipated, that the Online learning journal is a multi-faceted course accompanying method, which has been evaluated very positively by students as well as teachers. The subsequent planning contents for the Online learning journal are therefore prioritized highly. Based on the evaluation two main objectives Obj1 and Obj2 are aspired:
Obj1) Teaching and learning promoting aspects perceived by teachers and learners, shall be maintained and further developed.
Evaluation results are:
a) Teachers provide security and confidence
b) Learners search for/need security and trust
c) Individual support/diversity/flexibility

Obj2) Identified teaching and learning inhibiting aspects shall be redesigned and/or adapted.
Evaluation results are:
d) Time aspect
e) Expectations and attitudes towards learners limit the capacity to act
f) Pressure
g) Lack of/poor communication among teaching staff

In the following paragraphs proposals for selected results (1-7) are formulated, as a complete planning structure would exceed the framework prescribed.

a) The contents of the Online learning journal should continue to be without an evaluation by grade. This creates a confidence-building working relationship. Furthermore it is important to give punctual feedback to the student's answers within the Online learning journal. Feedback on not understood contents provides security for the learner during the learning process.
b) The proposals formulated here are closely linked to those under a). The two groups are referred to each other in the teaching-learning process. The feedback obtained individually provides safety for students. It is therefore important to admit personal contact even exceeding the Online learning journal, *for instance via e-mail or personal contact in the teacher's offices*. The Online learning Journal as a structuring method of the learning process

seems to be very important to students. The weekly employment and continuity of the procedure gives security and satisfaction within the learning process. The structure within the questions (Category 1-3) causes routine during processing and is perceived as pleasant. Thus it is worth to maintain the *structure of the questions as well as the structure of the process.*
c) Concerns that are not of technical/content nature can be addressed. Individual concerns are not always concerns of the whole semester group, but still should be taken seriously. This includes, for example, that a learner is not able to understand a particular subject despite explanation or consultations. A further accompaniment of this person is possible due to Online learning journal. Here an elaboration of *future learning strategies, which offer individual support*, together with the student is desirable.
d) During the semester it became apparent that the time specification for processing the weekly questions was too low. Thus learners became unmotivated. During the group discussion it also became evident, that due to this restriction displeasure was spread among teaching staff. Questions could not be asked to the desired extent, because the boarder pronounced at the beginning, would be broken. The optimization proposal is *to not specify any time information*, as every student needs different amount of time for processing. The *scope of questions should be varied according to the need.*
e) The expectations and attitudes lecturers unconsciously induce in teaching learning events are a separate issue. During the group discussion, students were constantly compared with pupils. The image of the self-responsible student, which is spread in study programs is on the other hand hindered by the teacher attitude. They are confronted with acts of teaching that are similar to the questions from the classical school hierarchy. Future questions of the Online learning journal will be asked in a way, that they aim for *self-closing of an issue*. This is to enable the learner's independence and emphasize adequate handling.
f) During the studies performance pressure is perceived within students. The Online learning journal in software engineering aims to reduce this pressure at the end of the semester. Individual, *out of the closing date received answers* are *included in the feedback loop*.
g) Lack of/unpleasant communication within teaching staff leads to an inhibitory learning atmosphere among learners. These have a strong sense of how the feedback within the lecturer's team is working. *5-10 minute presentations* at the beginning of the lectures of next semester will inform future students about most important points from the weekly Online learning journal periods. Thus a regular *common current state* of knowledge levels is made possible.

VI CONCLUSION

> "Conversation leads to real understanding. Starting and excited by something puzzling, looking for the reason." (Wagenschein, Martin).

The feedback and reflection model presented includes all stages of a reflection process (levels 1-4). It starts with feedback units that are continuously linked to the teaching-learning context. The groups involved in the teaching-learning process are included. Communication between persons and groups of students and teachers implies a permanent activity during the semester. Circumstances of activities during courses can be analyzed and interpreted. The Online learning Journal offers the possibility to reproduce own knowledge as well as to address sensitivities detached from the lecture. This free space contributes to a situation-adapted feedback. In the penultimate phase of reflection practice the events during the semester are addressed. Also this phase is undergone by both groups of persons.
The research methods selected for this application could be adequately replaced for example, if the group discussion, the online survey or the evaluation method (qualitative content

analysis) is not practicable. It is important to conduct the scientific survey of teaching-learning events when participants are present. The online survey was chosen because of its low-threshold use. It also represented the last task at the Online learning Journal. Participation of all students was assured. All teachers were able to attend the group discussion except one.

The evaluation of the data, the open-minded attitude during the evaluation, turned out to be one of the most challenging tasks during the reflection process. The results form the basis for further development of an activating-university teaching. The added value of the feedback and reflection process compensates the high time expenditure as well as personnel use during and after the semester.

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BIOGRAPHICAL INFORMATION

Magdalena Beslmeisl is a scientific officer at the OTH Regensburg in Germany. She works in an interdisciplinary project which aims to optimize the education of software engineering in higher education. Her task as a pedagogue is to develop experimental didactical strategies especially in software engineering. She researches in a self-reflective way to optimize teaching conditions to activate learners in an adaptive way.

Active learning in a deductive environment – what to consider to increase motivation and conceptual learning

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ABSTRACT
The disappointment in performance of students in engineering education in traditionally deductive shaped university teaching calls for other learning environments and different teaching format (Staffas 2015). This article compares the incoming abilities of bachelor and master's students in a 2^{nd} year electronics course with respect to their test results and their demonstrated and experienced conceptual development and how active learning principles based on voluntary participation affected their motivation. The study suggests a relation between the outcome of the exam and the incoming ability and/or previous grades on courses, and establishes factors that motivate the students to work hard or simply give up. It also reveals factors that make the students either motivate themselves or lose grip of their effort. The conclusions is that by pushing and motivating the students that probably will otherwise fail the exam, they become aware of their situation and find ways to increase their motivation and engagement to work harder and how to study more efficient. This will give them knowledge on how to attack the difficulties of the course aims and increase their chances to pass the course. The study methodology is narrative based on semi-structured interview questions, test results and an ability test given in comparison of previous and later results on courses they attended.

Keywords: motivation, conceptual learning, active learning

I INTRODUCTION

Keith M Parsons (2015) sends a message to his freshman students at the university: "You need to learn to listen. …I am your professor, not your teacher. ... It is no part of my job to make you learn. At university, learning is your job – and yours alone. My job is to lead you to the fountain of knowledge. … Universities are ancient and tend to do things the odd-fashioned way." Bob Hamman (World's # 1-rated bridge player for 20 straight years) dedicates among three things what made bridge his career choice: "To the college professors whose classes were so boring I couldn't help but focus on bridge" (Hamman with Manley 2011). Of course you can give the most entertaining lectures and satisfy lots of students, but if you only listen, this will make you passive and what you hear is soon forgotten. If you are bored as well it is even hard to pay attention and therefore nothing to forget… Learning is an activity so the instructor's role must be to give the students the best premises to work with the course content. Although lecturing has been the tradition of universities for hundreds of years it is in contradiction to Darwin or any evolutionary biologist that the humans continuously develop their skills, both as an individual as for the human kind. Why should a university perform teaching like it always has? Is the transition from chalk and talk-professors that hard, or even impossible to do? What does it requires that is so hard to adapt to? I started my university career 15 years ago as a genuine chalk and talk-lecturer but mixed it up with projects and active lessons to stimulate the students to learn. The main difference between now and then is that I did not really care whether the students passed or failed. Nobody seemed to care and I must admit that it was kind of nice knowing that I had all the power to decide what to do and the students just had to adapt. However, only in the last decade there have been some changes in the university world. First of all more students are forced into higher education from a more demanding labour market. Second, the explosion of information available and the possibility to post your own "knowledge" online has led to a global community where the boundaries and limitations on where to find knowledge are close to be erased. Third, research in teaching and learning and development of teaching (because of 1 and 2) has grown during the last decades. The modern human being seems not satisfied, neither as a student nor a teacher. Who wants

to perform bad teaching and get attention because of bad course evaluations? That woke me up at least.
When trying to create active learning environments and support students to reach conceptual understanding of the course content there is a number of possible instruments you can use. There are web based teaching, assignments, group work, projects, continuous examination (see for example Prince (2004) for a closer description on active learning and its use). It is though not enough to just present and execute efficient teaching and learning opportunities to inspire and force the students to get a grip of the course content and work hard enough. It is quite common that students either is confident in studying old exams and pass that way, or just cannot motivate themselves to get going and dig into the content and therefore becomes lazy, almost paralyzed. The number of students that must put in more effort to pass increases as the number of students increases. In courses that are more demanding this often leads to a large number of students not passing the exam. To motivate and engage the students likely to fail I have chosen a teaching model based on active learning, mostly PBL (Problem or project-based learning, see Kolmos, Fink and Krogh 2006 for a description of the Aalborg model), and tried to create learning environments where the students can benefit from the best of lectures, online learning, problem solving, group work under facilitation and more or less free projects. The course has been highly appreciated both in comments in the course evaluations as well as the general grade the students have giving it. Especially the web lectures and the group work are mentioned. But the outcome of the first part, a mostly theoretical survey of semiconductor circuits in analogue electronics, has been a disappointment.

II BACKGROUND

The study took place at a course in electronics the second year on a 2nd year combined bachelor and master program in electronics engineering at Uppsala University. As many as 80% (37/46) of the students' passes 50+ out of 60 credits in the 1st year and still 69% of them fails the first part (of four), and finds the course so much more difficult to complete. This study focuses on this first part, by tradition the hardest part of the course, and the factors that influences their motivation to study hard, and the factors that make them give up or not finding engagement to work hard enough. The planning of the first part is based on active learning such as PBL and ELT (Experiential learning theory). Experience became central in learning theory in the 20th century when John Dewey, Kurt Lewin and Jean Piaget, to mention a few, presented their theories of human learning and development. The theory is built on six propositions how new knowledge is gained (see Kolb, Kolb 2009). Facilitated group work and flipped classroom are used besides lectures and student active lessons. In a perfect world of group work there would be a very small portion of students that does not pass because not only will the combined experience and knowledge increase the problem solving ability, but it will also increase the motivation and engagement for the students to together reach the course outcomes. Therefore the groups need a stick (the exam and the assignments) as well as a carrot to get the most out of them and feed the process of learning and studying. To put learning for adults in a theoretical perspective you can apply for instance Kolb's the Learning cycle (Kolb 2014) to describe the process you have to go through to reach conceptual understanding and knowledge. An outline on his learning styles and experiential learning is to be found online by S.A. McLeod (2013). If you can implement an environment where the students´ work follows a similar pattern you will most likely provide them with the best of pre-requisites and make sure that as many as possible passes. A clear advantage to encourage group work is to support all the different learning styles according to Kolb that are represented in class. It is necessary to find ways that prohibits the individuals to give up or become lazy. Therefore the groups' needs to reflect on their newfound knowledge and formulate new experiences based on the conceptual work that has been done. The course coordinator can (shall) make the group evaluate their performance themselves, AND measure the conceptual understanding individually. This makes the learning process more transparent and the teacher/tutor can at an early stage determine which of the students that probably will not keep up with the curricula.
The selection of groups was made by the students, as suggested in the Aalborg PBL model. They were instructed to form groups of 6-8 and hand in the names when they were done. In case anyone did not get a group I emailed or announced it on a lecture/lesson. The grouping process is seldom a problem when it is the students' responsibility. Often there are a number of students left over and they normally

form the last group. It would though be interesting to decide as an instructor who works with who based on ability test, previous grades, and what kind of learner they are. This is yet to be done though.

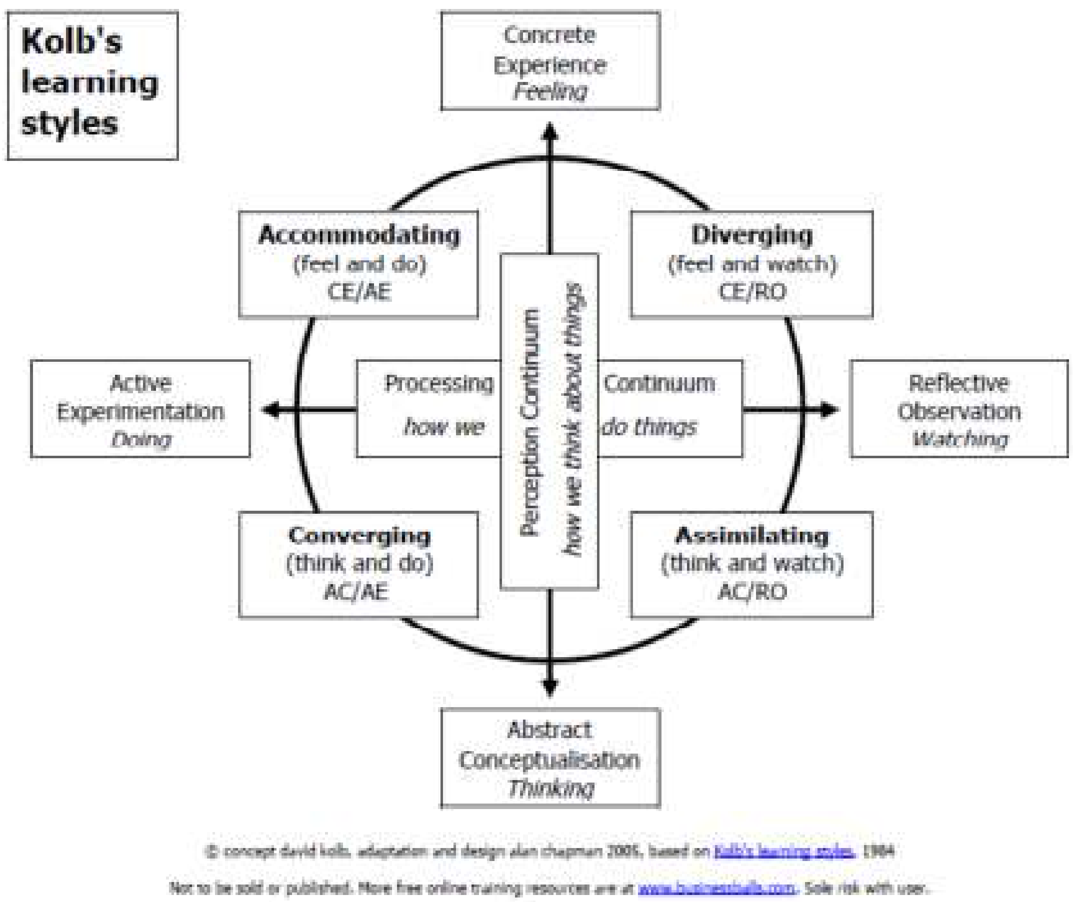
III PROCEDURAL AND CONCEPTUAL UNDERSTANDING

In this paper the procedural understanding is interpreted as how to solve a problem (in steps) in a well-defined procedure to follow. Conceptual is when you can take your previous knowledge and experience and learn how to solve new problems when the conditions changes. The construction is mainly based on Hiebert & Lefevre (Ch 1 in Hiebert 1986), but there are other interpretations as well. I will not go in to a deeper discussion about the definitions in this paper although it is of great interest.

IV LEARNING STYLES IN GROUP WORK

In higher education with groups of 50+ students, and also the fact that you must be allowed to set some kind of bar of engagement, it is impossible to focus on each one of the individuals. However you can make them aware of, or even determine, their learning style and create environments where they can maximise their possibilities to learn conceptually. In forming groups of 6-8 students you have the base for satisfy all kind of learning styles. There lies the responsibility on the group and you can provide them with the tools needed to evaluate the work put in and knowledge earned on a weekly basis. This is the key ingredient for learning in PBL. It is used to increase self-motivation and create cooperative learning and develop the self-learning abilities.

The four basic forms of knowing; divergence, convergence, assimilation and accommodation, as presented by Kolb (2014) set into his perspective of learning activities, forms the base of ELT. Learning is defined as “the process whereby knowledge is created through the transformation of experience.” (p. 49). The experiential learning model describes four modes of grasping and transforming experience, see figure (http://www.businessballs.com/kolblearningstylesdiagram.pdf).



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The convergent learner is shaped for higher education learning. The dominant abilities are abstract conceptualization and active experimentation making them suitable for a hypothetical/deductive reasoning on technical tasks and problems. They are particularly strong in problem solving, decision making and practical application of ideas.
The divergent learner has opposite strengths from the convergent, emphasizing concrete experience and reflective observation. Here the abilities are to view concrete situations from lots of perspectives and organize the relationships to a meaningful entirety. They are particularly strong in presenting alternative ideas and implications such as brainstorming.
In assimilation the students´ strengths is in inductive reasoning and creating theoretical models. The main difference between this type compared to the convergent learner is the focus on getting it theoretically and logically correct, not the practical use or value.
The opposite to assimilate learners is the accommodative learning style. Concrete experience and active experimentation are the key ingredients to learn new things, "doing things"; the trial and error-type. This learner is not so analytic and needs ideas and information to perform well.
When presenting group work as part of the planning the awareness of these learning types should be helpful in the process making them more effective together. Also on an individual level they become aware why they respond differently and can more easy fit in the group process.

V MOTIVATION, TEACHING AND LEARNING

The primary motivational factor for our actions, besides human need, is according to self-determination theory (See for example Deci & Ryan 1980) voluntariness. Studies (Ryan & Deci (2006) and more) show that when students experience barriers like tests and grades controlling their conceptual development they will lose interest in learning.
According to Shernoff (2013) instilling or supporting a continuing motivation to learn may be the most important underlying purpose for schooling (Sarason 1995)

One way to break down motivation is intrinsic and extrinsic (Carrot and the stick): The outcomes from extrinsically motivated individuals may be worse in terms of conceptual understanding, creativity, and longer-term continuing motivation (Sansone and Harackiewicz 2000). My experience confirms a better study climate when the students have an option to choose whether to participate or not. That means that all the compulsory moments are directly connected to the examination. The students are there because of their own will and the process characterizes to be more driven towards understanding and finish the task.
Professor Keith M. Parsons (2015) believes that the students' activity shall be to listen and then learn by themselves. So the course content itself and the excitement the lecturer creates is the primary (and only) motivational factor. Listening and reading are far from interesting all the time, especially if someone tells us to. If you are a believer in learning by doing and methods based on student activities you should focus on ways to inspire your students to study. The teaching shall encourage discussions on a conceptual level and prepare them for projects and/or problem solving. There is otherwise a risk that your classes merely focus on what to learn to pass the exam.
When discussing teaching from Parsons point of view as a "chalk and talk-professor" he continues: "Hogwash. You need to learn to listen. The kind of listening you need to learn is not passive absorption, like watching TV; it is critical listening. Critical listening means that you are not just hearing but thinking about what you are hearing. Critical listening questions and evaluates what is being said and seeks key concepts and unifying themes. Your high school curriculum would have served you better had it focused more on developing your listening skills rather than drilling you on test-taking."
So is this the way to meet the students? Shall we blame the earlier schools they attended and try to foster them into an academic culture they do not know? According to the article the students have to learn a new authority and way of teaching (listening!), but in my point of view teaching need NOT to be any different in kind of methods and approach as those in earlier schools, BUT what changes is that there should be no doubts on who will do the work towards understanding; the instructors role is to create engagement and learning environments for the students to study (hard). We shall therefore NOT foster the students to accept a new way of teaching "the old-fashioned way", merely make the students

understand that the learning is more conceptual and needs more time and effort than before. Also they will be forced to do a lot of the reading in their own time so they need to learn to discipline themselves.
Motivation and engagement is about discipline, or the ability to discipline oneself. Can we create motivation to study by remove some obstacles? What are the obstacles? Motivation can be about relations instead of absolute values. I as a teacher have the possibility to create motivation through how I present the curriculum and its contents and create a learning environment where the students' engagement is raised and therefore succeeds. So from a teachers view motivation is a crucial factor that is controlled by power and opportunities. You can force someone to perform, but it would be better to use the power to give them possibilities to increase their motivation, and more important, turn around some of them who will get lost when the problems arise to mountains where giving up is the easiest and most common reaction.
What will then be the difference for the teacher? How much more time and effort does this mean? There is a borderline for a university teacher in what efforts he can put in. On one hand it is important that the teaching and curricula includes all the elements necessary for the students´ to partly pass the course, and partly fulfil the course requirements, on the other hand it is important to motivate the students to work hard enough to pass the course. This in particular has been even more important for political and economic reasons since the system for governmental funding's having changed. Earlier you got paid for giving a course, regardless the outcome of the course in number of student´s that passed. Now it is bound to the number of students´ that actually pass the course and graduate from each program and the quality the programs holds. (http://www.uka.se/faktaomhogskolan/universitetenochhogskolorna.4.782a298813a88dd0dad800012056.html). It might be a tradition to almost entirely focus on the content of the course and what to exam instead of mixing it with ways to motivate the students to avoid defection and lack of motivation to study hard enough. If both components shall be covered it is necessary to do some adjustments if you are not putting in more time and effort in your teaching. One way is to create learning facilities that promotes students to work hard by themselves; i.e. not be dependent to have the teacher telling how to solve the problems that should be learned. So using student active methods can release time to focus on methods to motivate and support the students to increase their effort and motivation instead of merely prepare lecture, lessons, seminars and laboratory experiments. My experience is that the numbers of lectures and lessons given have increased. Offering different learning environments like above and reduce the number of lectures and lessons will more likely even it out. So instead of adding time on more lecturing, the time is better spent establishing contact with the student more as a facilitator and a team leader towards conceptual learning, i.e. you take full responsibility for the learning process as a teacher.
Even a philosopher like Kierkegaard believed that true instruction begins when instructors understand their student (Kierkegaard & Auden 1999). I would like to turn it around some. Of course it is of great importance to know your students, but how often can you establish that contact when classes exceeds 50 participants? You can generalise groups of students and get a decent hit in terms of graduates, but why aim for an average? If you can't invite your students to a four eye relation you can at least start by learning their names. If you learn their names you can from lecture two establish communication to the group by addressing direct comments and/or questions to the audience hence improving the teaching to be two-ways instead of just information, or "a steady stream of continuous talk" (Shernoff, 2013, p. 132). In groups larger than 50 you are more likely to be several instructors so why not divide them into manageable groups? There is no prize for lecturing the most students!
However, not all the students come from learning environments that has created engagement. According to Shernoff (2013) the one best system school in the 20th century took out all the creativity and looked at the students as a group and therefore, despite what we know about how humans learn are motivated, schools didn't teach that way. Further from Shernoff (p. 11): "A substantial literature has been established that student engagement positively impacts academic performance and achievement (Kelly 2008; Marks 2000; Sirins and Rogers-Sirin 2004; Voelkl 1997; see Fredricks et al (2004) for a review). Unfortunately, the importance of engagement is therefore reduced to its relationship to achievement. However, engagement is an important outcome of schooling in its own rights. Mounting evidence suggests that engagement is a vital protective factor and leads to a host of positive educational and social outcomes and decreases in negative emotions and behaviours (Li et al

2014; O'Farrell and Morrison 2003)." So establish a relation to your students instead of just being an authority and invite them to be a part of the process of the learning environment will promote their engagement.
The autonomy of the learner is the absolute key to motivation. Any sort of compulsion is – psychologically speaking – close to a physical forcing in terms of its negative effects on intrinsic motivation or self-motivation (Deci 1996). So if you can combine your skills to create engaging and stimulating learning tasks and still have them voluntary you have built the best foundation for most students to study hard, learn conceptually, and, hopefully, taking another step towards autonomously as a learner.
According to Shernoff (2013) Albert Einstein considered knowledge to be "dead". So in order to gain knowledge we must "serve the living". "The training of the will" means that the create will, and not the ability to sit and be mechanically taught, "is the driver of learning" (p. 32).

VI RESEARCH QUESTIONS

How can a teacher predict which students will struggle to pass a course? How do students' that fails respond in terms of motivation and engagement? What can be done to help these students to increase their conceptual understanding?

VII METHODOLOGY

The survey is a narrative study made from 42 semi structured interviews of students where they were asked how they experienced a course planning, their experienced learning, working in groups, and how it affected their motivation and self-efficacy.

VIII THE INTERVIEWS

For the first interview all 46 students of the course were invited and 42 participated. The structure of the interview began with an icebreaker (Creswell 2009) where they freely could describe whatever came to their mind on how they experienced the course and its planning. The rest of the interview was based on three key areas; the planning, their experienced learning, and their motivation and self-efficacy. As support the following questions were pre-prepared on the motivation – self-efficacy and learning part:
What changed for you during course: did you became more motivated, got better self-confidence, studied more or harder, got a better hold on what you were supposed to learn?

Do you have better knowledge on what you need to know as an engineer?

How much time do you study each week? How much time would you need? Why don't you put in that?

What is the most important reason for you to participate in this course?

What do you consider to be the most motivation factor to study hard on a course?

Has the group work functioned? Is there moments that has been better or worse? Are there moments where the group has held you back? How do you experience the engagement of the group members? Is it an advantage to have been working in groups before you enter the project phase of the course?

This was by no means questions that everybody got, more like a memory card for me to keep the questioning on the right track. The overall goal was to figure out how the planning that included them working in groups affected their motivation, learning and engagement.

IX RESULTS

The tests

Out of 46 students 42 took the voluntary ability test. The test contained 13 number sequences and their task was to determine what number comes next. There were some easy ones like the power of 3 (3, 9, 27, 82,…) and increasing difference (3, 5, 9, 15, 23,…), some more challenging; 4, 2, 16, 5, 3,… and 27, 82, 41, 124, 62, 31, 94, 47, 142, 71, 214, 107,… and one really tough that no one solved. I estimated six of them to fairly basic (just one operation needed), and the rest needed more than one operation or a combination of the previous numbers to figure it out, so the total of seven correct answers was my presumption that they should manage to "pass".

As can be seen only 13 managed to get more than 50 %, i.e. 7+ correct answers. I was quite astonished that as many as 10 only got three correct answers. During the first part, the more theoretical and abstract, they had a written exam and were offered to write a voluntary conceptual test where their understanding of electronic circuits was examined, without more than trivial calculation. It was quite clear that there was, not surprisingly, a clear connection between a poor result on the ability test and the outcome of the exam. When combining the result from the ability test with their credits from year one it was even more clear who was expected to fail and who to pass, see the table below. So when preparing for a course students normally having difficulties to pass a simple ability test and a look at their previous credits will give a good indication on who will pass and who will fail. What about these five that still performed really well? A closer look on their completed courses showed at least two top grades and no credits left behind. With that in hand a simple test on sequences gives you as a lecturer a powerful tool to spot the students that probably will struggle passing the exam. In the table the first three columns are the necessary conditions for column four.

1. Result ability test	2. Hp year 1	3. Result exam	# of students (1&2&3)
< 7	< 60	Failed	13
< 7	< 60	Passed	1
< 7	60	Failed	10
< 7	60	Passed	5
≥ 7	< 60	Failed	4
≥ 7	< 60	Passed	0
≥ 7	60	Failed	1
≥ 7	60	Passed	7

Table for the outcome 1

There were four that did not take the ability test. Three of them had the maximum 60 hp from year 1 and passed the exam. Two of them with excellent grades, one made it barely. The one with less than 60 hp failed the exam.
The one that passed the exam in the second row described himself as a survivor. He is a bit older than the average and claims to have a good insight in how to "get by".
There are two groups of students that even at a more demanding course (like this is) appears to be self-regulated learners. One of them is obvious; having the mathematic ability AND a clean sheet from previous studies. The five students that performed terrible at the ability test, had the maximum credits for year one and still passed, passed with really good grades. What separated them from the group with a "better" ability result? Do they learn in a different way? What is their way for success? They were selected for a follow up interview to try to establish why they had such a low score on a fundamental mathematic test and still performed at a conceptually high level. The set of questions guiding the interviews were:

Question 1: What do you think of the test and your result?
All of them claimed not being used to the task and needed time to prepare for the test to perform well. The time pressure set them back
Q2.1: Does the test reflect your mathematical skills? Is there something missing in the test?
They would have preferred tasks connected to real problems and/or an IQ test.
Q2.2: Did you give your best effort or just want to finish it?
Some attitude issues could be spotted: nothing was at stake.
Q2.3: How come the test result differs so much from your previous results on the program?
In their previous courses it is more about learning patterns to solve problem, learn a structure. They need the time to sort it out.
Q3.1: What course do you like the best so far, math course and overall?
Math: +: Single variable calculus -: Transform theory and Algebra
Overall: The actual course -: different for all of them
The course had to appear useful was the common denominator.
Q3.2: Is the planning the reason for your opinion?
Yes from four of them, no from one. Important that the courses are connected to practical problems and utility.
Q4: How do you learn math or courses that uses math best?
Understand the structure and learn from the ground up.

It showed that they lacked the ability to cope with real numbers and felt pressured by the time limit. They also claimed never been doing this type of test earlier, but still claimed to be good mathematicians. The common denominator for all of them was being persistent. They simple hold on to the task until they felt they have understood the concept. So they were committed to the task and the belief that they were good in math. An interesting observation is that they seem to need time to understand and learn the concept to perform at all: they feel almost new to all tasks and need the time to get into the concept. So the difference in learning is that they lack the talent for numbers intuitively (the concept) but with time they have a really good capacity in learning the recipe for solving the problems (the procedure). So when they cope with written exams based on textbook problems they have the ability to learn all of the recipes to solve each and every one of them. See below on suggested further investigations. In further investigations I suggest a follow up on these students.
From the students that scored 7+ on the ability test four out of twelve failed the exam. Three of them had not full credits from year one. So it becomes even clearer that a clean sheet from the previous courses is a very good predictor on who will struggle to pass.
A strategy is needed for those students who are not there to enable them to be more successful and learn how to coach themselves to understand what they need to study more efficient. Should you make them aware of that they probably will fail the exam? I think so but this can only be done by total honesty and should be done when the ability test and the analysis from their previous performance have categorized them as members of the group that will fail presumably. This is of course a delicate situation that calls for a well prepared meeting pointing out ways to tackle the course content; Give them a clear path on what they will have to go through to pass.

Conclusions

Although there is a no clear connection between their previous results combined with the outcome from the ability test, the union of the two is a very accurate tool to use to spot students that are in the danger zone. If they fail the ability test but have passed all courses they can still have the ability to learn conceptually. The mentioned five that had passed all courses but got a low score on the ability test passed with ease, four of them earned top grade. These five had at least two top grades ("5") from the first year. So students with a low score on the ability test or not completed all the previous courses (with ease) are in danger of not passing a course that is considered more demanding and normally has low throughput. Students with a good ability score and completed courses (without missing any) shows enough motivation and self-wisdom to process the information as well as the teaching to pass. They have simply become self-regulated learners.

X MOTIVATIONAL PROBLEMS

Two categories of students can be spotted amongst them who fails the exam (Staffas 2015). One of them becomes lazy, and the other fails to sort things out and get lost in the flow of information and opportunities to learn. The need for deadlines on the assignments was a reflection many of them did. They simply started studying hard too late. Although they participated in the lectures they quite soon discovered that they could not follow the content of the lecture and the spiral started spinning downwards. The lack of time spent by them studying on their own (besides scheduled classes) was apparent. Despite the fact working in groups they merely just tacked along with the rest of the group without really know if they understood or not; they could always get someone to show them a solution. The students that passed praised the planning to be really motivating, encouraging them to start their own projects based on the conceptual approach to the lectures and lessons. The need to create your own motivation inspired them. Despite the fact that the lazy students liked the planning and understood what to do their own effort became too low and excuses like the environment within the group was too noisy and giving priority to a parallel course was mentioned why not enough time was spent. A key moment was when complex numbers were used to solve problems in logarithmic diagrams; here the complexity went to high for many of them driving a large nail into their engagement sinking the motivation to catch on. For them, study hard close to the exam was not simply enough to catch up lost ground.

When interviewing them who failed exam the focus was on what factors made them fail. Obviously they do not put in the amount of time needed, but several of them claimed to have worked really hard and still did not pass. They could not benefit from the appreciated teaching and group work. The fact that they fail is grounded in a misbelief in how to study and how they learn.

There is a barrier to climb for many students: even though I repeatedly encouraged them to not hesitate to ask questions and contact me whatever they want, and on numerous occasions mentioned "I'm here for you", many of them who failed mentioned the fact that they chose <u>not to</u> talk to me when having trouble.

"When the going gets tough I gear down!" "All the information was there. You just had to spend enough time to succeed." was mentioned repeatedly from the ones who failed.

Taking notes is another interesting subject. Some of them claimed that they did not have that much use of the lecture notes; some even complained that they were blurry. At the same time they really liked the web lectures and studied them more than once. It seems as the conceptual view of a lecture which goal is to create communication in the classroom and inspire them too think of the problems in a practical context somehow confuses the weaker students. Give them handouts in advance is something I do not believe in since it makes them passive, but maybe hand out sketched solution proposals on the selected problems afterwards, encourage them to only write down what catches their attention during lecture, and focus on writing down what comes to their mind, instead of trying to copy all that is written on the blackboard.

Conclusions

The need for tests confirming their newfound knowledge becomes obvious to insert. Since I am a firm believer of a carrot and voluntary activities in front of a stick, weekly conceptual tests seems like a recipe to actualise. It will primary solve two problems besides the forcing effect; first a direct feedback to their studying last week, and second information for the instructor how the work bore fruit and material to use to summarize and point out the obstacles they experienced analysing their answers. They can take the test online and get immediate feedback on each conceptual question. Since there are two major differences in students' capability and motivation two weekly tests is probably the best. One "must know" and another more advanced. This also gives the students another feedback on what a reasonable ambition should be. And maybe also a carrot for those not so capable students to study really hard and reach a higher grade than just barely pass.

Since the majority of the students only study at school the group work could be designed to include responsibilities for the group and make them aware that all the individuals shall participate and take the weekly tests. The facilitator's role must be extremely clear to not just answering questions that pop up at the moment. It is the groups' responsibility to methodically work them through the weekly content and consider what there is to be processed with the teacher/tutor. When they get stuck there is lots of help to be found at the internet.

Simply teach them how to take notes. Start every lesson following a lecture with them asking their questions from the lecture. It is about creating a culture based on active listening and reflection on the conceptual content.

XI THE TEACHING MODEL

"In a regular course you just put your head down and move on and the lessons turn up when they come."

For those who became lazy it was apparent that they thought they needed sticks to perform. Right from the start they would have wanted a clear goal to inspire (force) them to dig into the course content. Weekly conceptual tests and an early small exam could probably have motivated them. The group itself can create responsibilities amongst them on what their goal for the day/week shall be. The students in the danger zone are made aware what to aim for and therefore should be more motivated to participate in the group work. It is important to point out for those who are in danger of failing that a difficult course means much more time spent studying. Make them work practical with the theory from the beginning motivate them to work harder; it is much more easy to spend several hours in the lab then just solving textbook problems.

Several claimed to understand the lectures and then when trying by themselves they got stuck. It becomes apparent that somewhere in the process where they work by themselves or in the group they get lost despite feeling confident from the conceptual lecture. Maybe a test after the lesson can help them realize what they clearly don't get? This could be done by clickers or similar at the end of the lesson (Mazur 1997).

Conclusions:

So present laboratory work right from the start is well in harmony with the theory to learning by doing and well spent effort for the teacher. The need for structure is apparent for them to get going right at the start. So you should address a task for the group on a weekly basis and let them hand in a report on how the work proceeded.

For those who having trouble sorting it all out it is necessary to provide them with the tools to perform on a daily and weekly basis. "This day we work on A, the next day is B processed. To earn enough knowledge to pass these assignments and problems need to be solved. You can check if your newfound knowledge is good enough on the weekly conceptual test given." and so on.

The awareness of the whole is a clear motivating factor. If the content is well situated in the planning it becomes more clear for the student to understand what they are supposed to learn and why.

XII **ADDITIONAL OBSERVATIONS**

When working in groups the suitable size of the group differs on different assignments. Theoretical parts and problem solving is better done in larger groups, 6-8, but projects and practical work operates better if the group size is reduced to a maximum of three or four, The reason is that in larger groups there is a risk that some of the participants becomes assistants to the creative and fast ones. Even though they split up and work on their own to come up with ideas some will become more dominant than others and therefore the weaker tends to be pushed away into the shadow and merely accept the others proposal for solution. Projects driven by the teacher provides in general no problem working in larger groups, but more free projects driven by the students is better suited for smaller groups. When it comes to writing reports, it is difficult and not particularly appropriate to the larger groups. Therefore a report written on a project done by 6-8 students is better done in groups of two, or maybe three. The different writing groups can then meet under supervision and discuss their reports to verify what they wrote and what should have been written. This then becomes an excellent opportunity for the individual marking. Most students enjoyed working in groups, so the environment for learning is there. But as written before there has to be more focus on the groups responsibility for each other and a possibility to be aware of what I learned, for example by online tests.

The time factor: Nearly all of them who failed worked less than 40 h/week. That is despite the fact that they enjoyed the teaching and learning facilities, especially they stress the sequence of web lecture – conceptual lecture – lessons working with the fundamentals – the group work on this week's problems. On the other hand when the step between each teaching part seems reasonable the environment creates a fun challenging and rewarding course that gives an understanding for the whole based on your own thinking, not just abrade into solutions. Therefore it is even more important to address the students in danger for failing and enlightened them on how much work they need to put in and not trusting the intense exam studying they are used to when it is too late.

An almost 75 % failure on an exam in a math course in first year because of different structure of the exam shows the students trust in studying previous exams instead of learning the content on a conceptual level. Projects are good for the motivation if you are interested. Therefore the projects (and problems) have to attract the students; the teacher/tutor needs a good selling argument. It is not the work form itself that is the blessing. It is the same to establish a student active learning environment: they need to see the benefits from it. Just doing something different is not what sells the concept.

The need for helping the student to know them self and their limitations and how to learn is apparent. Almost all the students that performed well pointed out the benefits from the scheduled time where they were supposed to work in their groups. It helped them to be disciplined and also benefit from the members when working together. They worked until they solved the proposed problems and some of them continued in the laboratory working with applications of the newfound concepts. They were encouraged to do so but that was almost mentioned from the back bone expecting that no one would care.

XIII FUTURE INVESTIGATIONS

A couple of loose ends emerge from the investigation. The most suitable group size in different moments of the course and the students that passed the exam, despite some of them performed terrible at the ability test.

How shall the group composition be? They should choose the groups for them self but how large shall the groups be? What is the advantage of study groups of 6-8? Can a group of just 3 or 4 be as effective despite the fact that the students are in the danger of failing the exam? Despite the fact that they know the instructor is there for them, what makes the students hide and prefer to stay invisible and fail?

How to present and instruct them to use online help during the course is something to investigate. Should there be an evaluation of what is found? Should there be sessions where the teacher discusses different forums on the subject?

XIV FURTHER READING

In the paper *A student active learning model in a deductive environment (Staffas 2015, yet to be published)* a complete teaching model and how to implement it is described based on the conclusions in this paper and Experiences from a change to student active teaching in a deductive environment: actions and reactions (Staffas 2015).

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Experiencing engineering field work in Greenland through summer courses in Arctic Technology

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ABSTRACT
Generic competences, student diversity, project family

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

Three different courses within Arctic Technology are offered to engineering students enrolled at DTU. The main teaching activity is a 3 weeks field period in Greenland during the summer, where the students work on a specific engineering or research project, offered within several engineering disciplines in close collaboration with local stakeholders. Two of the courses introduce the students to the Arctic for the first time, whereas the third course is part of the Bachelor in Arctic Engineering education, where the students have lived at least 1 year in Greenland at the time of the course. Thus, there is a high degree of diversity among the students; nationality, educational programme and semester.

The main objective for the courses is to teach the students to do field work in the Arctic. By actually going to the Arctic and applying their skills, the students get valuable first-hand insight into working as an engineer under the challenging conditions and limited infrastructure that exits here.

The courses have been running parallel for several years, with little integration of the curriculum. From 2014, some projects were made in project families similar to Ottosen et al. (2014), aiming to share knowledge and experiences between the students across the courses for increased learning outcome. During the field work, the students are acting as project managers for their projects and experts in relation to local stakeholders. The results of the projects are presented at a civil meeting in Greenland and all reports are available online for stakeholders. The effects of the project families were evaluated by observation of the students working together, the assessment of the different courses, achieved competences by the students, course evaluations and focussed interviews. The students evaluate the courses as highly motivating and for the students working in project families; that they could not have achieved the same results and understanding of the local conditions in their projects if working solely on their own.

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Teaching Change Agents for Active Learning in Engineering Education

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ABSTRACT
Teacher training, dissemination competence, active learning, engineering education, first-year students

INTRODUCTION
The paper will describe the pedagogical training of "Teaching Change Agents". They represent a special and new category of teaching staff at TU Berlin recruited for the implementation and dissemination of active learning approaches, mainly for first year students. They are qualified by a tailor-made mandatory training, designed with regard to their specific roles and the necessary competences. Based on the course offers for the still voluntary pedagogical qualification of academic teaching staff in general, an exemplary curriculum for the qualification of these change agents has been developed. Experiences with this qualification concept and with efficient training methods will be outlined. Preliminary results of the impact of the approach will be presented which are based on answers to self-evaluation questionnaires for the involved students.

BACKGROUND & EXPLANATION
TU Berlin is one of the largest technical universities in Germany with about 30 000 students. High numbers of first-year students, 1000 or more in introductory STEM-lectures, make teaching and learning often challenging. In addition to about 300 full-time professors teaching 9 hours per week, the teaching staff comprises nearly 2500 research and teaching assistants, normally contracted for 5 years. Besides working on their doctoral theses, they are obliged to teach at least 4 hours per week. In many cases, they have neither previous didactic nor pedagogic qualifications, but can achieve respective competences on a voluntary basis by our TU Berlin teaching staff training. Within a special programme for the improvement of study conditions and teaching and learning at universities, funded by the German Federal Ministry of Education and Research, we developed the approach of "teaching change agents". They have to design and implement new active learning based courses and in this context also contribute to the pedagogical training of their colleagues.

SET UP
In order to monitor the impact of our approach we designed a questionnaire for the students, mainly focused on concrete learning activities. Preliminary results indicate that more than one third of participating students perceive their learning outcome to be above-average compared to standard lectures at TU Berlin. In addition, activating teaching methods also seem to increase the perceived quality of the students´ own learning process compared to other lectures.

EXPECTED OUTCOMES
The long-term goal is to implement an innovative and interactive teaching and learning culture, corresponding with a student-centered didactic approach, the impact of lifelong learning and professional support structures at university and in faculties. Therefore, we aim at qualifying all teaching staff during all phases of their teaching career. The training for teaching in higher education and professional counselling for teaching change agents is based on the existing certified programme for teaching and learning (accredited by the German Association for Academic Development). It is complemented by tailor-made offers, supporting individual needs. With these competences they act as disseminators within the faculties and departments and provide counselling and workshops about good teaching practice in their fields to colleagues. They also develop innovative teaching concepts and projects for their own subject-specific teaching. Thus, they make staff and organizational development work hand in hand. The implementation of the necessary change requires organizational and curricular developments (support structures) in addition to teaching staff development.

Session type: poster

Using project families to activate students in the lab

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ABSTRACT
Project cooperation with Industry, Authentic Learning, Facilitating student creativity and innovation, Large classes.

Engineering students should be more independent and active, especially in their final thesis project. At the same time expected that the students cooperate with the industry, produce innovative solutions, good reports and presentations. This can often lead to a number of challenges for the students, supervisors and the industry involved in thesis work.

The Department of Civil Engineering at DTU has over the last years introduced a new approach to these project activities through introduction of project families, where a number of student projects have a common, but broad focus, problem or the same industrial partner (Ottosen et al., 2014). The projects are independent and run in parallel and focus on different aspects, approaches or problems, but may share test setups, information or meet the industry at some predefined times.

The experience from over 50 project students is that it has made the students more active, more independent. The students achieved better results (Ottosen et al, 2014). The projects are at the same time less time consuming to supervise, enable a more optimal use of the facilities, allow the students to progress further with their projects. It is the experience that the students work in project-families provides a real impact for the research, development and cooperation with the industry. The organisation of projects leads also to substantial amounts of peer-review, presentations, discussions and even peer-instructions without a major pressure from the supervisors.

It is, however, relevant to discuss how the concept of project families can be improved and how it can be used in regular courses prior to the final thesis work and how the improved quality of the student activities can be used for an improved cooperation with the industry. Some initial experiments have been also carried out in laboratory courses for large classes (100+ students), where the design of a special student lab equipment has facilitated the experimental activities and encouraged informal peer-evaluations.

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A problem/project-based approach to introductory artificial intelligence

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Keywords – problem-based, project-based, inductive methods, gamification, artificial intelligence
I am submitting a: **__X__ poster.**

I. Background

DIS is a non-profit organisation based in Copenhagen, Denmark. DIS offers study abroad programs specialised for American students (DIS 2015). An introductory AI course is currently under development by this author (start Aug 21 2015). The students are second years Computer Science majors (or older) originating from different American Universities. The course offers 23 lessons each lasting 90 minutes and imposes a 21-students cap. Completion awards roughly 7 ECTS. In what follows we describe a problem/project-based approach (Prince et al. 2006) to teaching introductory AI. Our focus is on student motivation and creativity facilitated by the use of open-ended problems and inductive instruction; as motivated by the crucial learning objective:

(L) The student is able to analyse, design and implement an *autonomous agent*.

II. A problem/project-based approach

We take a problem-based approach to stimulate the development of (L). To keep a form of continuity, problems are cast in relationship to the *Copenhagent* scenario. In Copenhagent, an artificial agent is cast as a newly arrived DIS student who must act in (a fictitious version of) Copenhagen. An example problem is travelling efficiently using public transportation, motivating e.g. *problem solving as search and heuristics*. For convenience, a single software package provides students with the necessary tools to develop an agent in this scenario. The current intention is to have one or two *task projects* and one or two *discipline projects* (de Graaf et al. 2006). Projects with substantial workload are carried out in groups. To reduce the risk of interpersonal conflicts and encourage collaboration, students form groups throughout the course. Minilectures and class discussions serve as the primary tool to facilitate student needs. This structure is chosen to increase motivation, encourage creativity and provide an adaptable teaching and learning setting.

III. Materials

We provide a custom developed software package, containing a graphical representation of Copenhagent, as well as boilerplate agent code for acting in this scenario (no programming language enforced). This reduces implementational overhead significantly. To achieve a form of gamification, we award points when an agent completes a problem (score optimisation is a standard problem in AI). Inter-student discussion is eased by this use of class-wide software and scenario.

IV. Evaluation

Naturally, the learning objective (L) is difficult to measure, not the least for students. The continuity of the gamified Copenhagent domain acts as a motivator, while also letting students reflect on what they have achieved throughout the course. A simple pre/post-test is administered in the form of a quiz containing questions related to the learning objective (L).

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ProofJudge: Automated Proof Judging Tool for Learning Mathematical Logic

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ABSTRACT

Today we have software in many artefacts, from medical devices to cars and airplanes, and the software must not only be efficient and intelligent but also reliable and secure. Tests can show the presence of bugs but cannot guarantee their absence. A machine-checked proof using mathematical logic provides strong evidence for software correctness but it requires advanced knowledge and skills. We have developed a tool which helps the student to practice their skills and also allows a better conceptual understanding of state-of-the-art proof assistants. Previously the proofs has been carried out using pen and paper because no adequate tool was available. The learning problem is how to make abstract concepts of logic as concrete as possible.

ProofJudge is a computer system and teaching approach for teaching mathematical logic and automated reasoning which augments the e-learning tool NaDeA (Natural Deduction Assistant). We believe that automatic feedback on student assignments would allow the students to enhance their skill in natural deduction proofs which are fundamental in formal verification and artificial intelligence applications. The teachers will benefit too and can put more emphasis on the semantics. Natural deduction is taught at most if not all universities but few tools exist. Initially we plan to have former students on the course to evaluate ProofJudge and later it will be employed in the course.

Keywords – E-Learning, Automated Tool, Mathematical Logic, Computer Science

I INTRODUCTION

Every year since 2006 around 70 BSc and MSc students in computer science have taken DTU course 02156 Logical Systems and Logic Programming (5 ECTS). The aim of the logical systems half of the course is to give an introduction to mathematical logic for automated reasoning. The students are expected to have a rudimentary knowledge of mathematical logic from previous courses on discrete mathematics (e.g. DTU course 01017) and/or artificial intelligence (e.g. DTU course 02180). The students are also expected to have taken introductory courses in imperative / object-oriented programming as well as in algorithms and data structures (e.g. DTU courses 02101 and 02105). This corresponds to 15-20 ECTS standard computer science bachelor courses. We will provide the most necessary background in the following section. In the remaining part of the introduction we describe the course, in particular its aim and structure.

In the autumn semester 2014 the grade average was 7.2 on the Danish grading scale, 85% of the registered students passed the course and in the anonymous but publicly available course evaluation 75% agreed or strongly agreed that they had learned at lot in the course (http://www.kurser.dtu.dk/02156). More than 80% found that their performance during the course was equivalent to the expected 9 hours per week and in the answer to the final evaluation question, “In general, I think this is a good course”, less than 6% disagreed and no student strongly disagreed. Similar good results exist for the preceding years and the course has only been adjusted a little from year to year.

The structure of the course is rather traditional:

- Textbook: *Mathematical Logic for Computer Science* (Mordechai Ben-Ari, Springer 2012). The first edition was published in 1993 and now we have the third edition.

- Exam: Mandatory individual assignments and a 2-hour written exam without computer (all written works of reference are permitted). Several sample exams with solutions are provided.

- Lessons: 13 weeks each with 2 hours of lectures followed by 2 hours of exercise classes with two teaching assistants.

Despite the rather traditional structure it seems that the students are active learners and that there is no reason to update our teaching. Nevertheless we are probably going to change more or less every aspect of the course in the coming years. Our goal is simply to teach more advanced topics while keeping it motivating and engaging for the students. It will be more fun and challeging for us to teach more advanced topics and the university and the society will benefit too.

The more advanced topics are not normally taught for BSc and MSc students. Elements have recently been considered in MSc and PhD courses at universities like TUM (Technischen Universität München), but these elements cannot be directly transferred to a course for BSc students.

No suitable textbooks are available for the more advanced topics. For more than a year we have been working on the e-learning tool NaDeA: Natural Deduction Assistant (Villadsen *et al.* 2015). It has been tested during the summer 2015 on selected BSc and MSc students and will be used in the autumn 2015 for the 70 students on the course (52 are Danish BSc students and the rest is a mix of international and Danish BSc/MSc students). Furthermore we have obtain funding for the development of ProofJudge, which is a separate component supporting student assignments and automatic feedback and/or grading, to be ready in the summer 2016. In the present paper we describe both NaDeA and ProofJudge.

NaDeA is available online (http://nadea.compute.dtu.dk/), but although there is quite some welcome information, a tutorial, exercises with solutions and a help system it requires basic skills in mathematical logic which we provide in the first 5 weeks of the course.

In the following section II we provide the background needed to understand the purpose of NaDeA and ProofJudge. In section III we elaborate on our design decisions, briefly discuss our results and conclude.

II BACKGROUND

This section provides the most necessary background on mathematical logic and automated reasoning.

Let us start with the following quote from the large 2-volume *Handbook of Automated Reasoning* (2001):

> *Automated reasoning has matured into one of the most advanced areas of computer science. It is used in many areas of the field, including software and hardware verification, logic and functional programming, formal methods, knowledge representation, deductive databases, and artificial intelligence.*

The kind of reasoning that we are interested in here is the reasoning in mathematics and science, in particular engineering science. By automated reasoning we mean reasoning by a machine, which in practice is just a program on a standard computer.

Today's computers are fast and can perform millions of operations per second. Since computers do not understand the purpose of the operations it is essential that the operations are correct. Otherwise a lot of incorrect reasoning will be produced in no time. In mathematical logic we study the correctness of the rules for automated reasoning. A few concepts has a longer history but

In *De Arte Combinatoria* (1666) Gottfried Wilhelm Leibniz was the first to tackle effective reasoning as a technical problem. But he did not get very far. In Augustus De Morgan's *First Notions of Logic* (1839) and *Formal Logic* (1847) and George Boole's *The Mathematical Analysis of Logic* (1847) and *Laws of Thought* (1854) we find what we now call the Boolean expression involving the so-called truth values (corresponding to 0 and 1 in the modern digital computer). But the first proposal including support for also the natural and real numbers we find in *Begriffsschrift* (1879) by Gottlob Frege. Unfortunately the rules are inconsistent such that we do not only have the truth 2+2=4 but also the falsehood 2+2=3.

Bertrand Russell's *The Principles of Mathematics* (1903) consists of 500 sections and with later simplifications of the rules we reach today's foundations of mathematics in the form of first-order logic and higher-order logic. Kurt Gödel showed in 1931 that all foundations of mathematics are essentially incomplete in a technical sense. Furthermore in 1936 Alonzo Church showed that even first-order logic is essentially undecidable and when Alan Turing later the same year defined the universal computer the limitations of mathematical logic was generally accepted. However, it is important to understand that these results are theoretical limitations of mathematical logic. Selected results about the limitations are briefly discussed in the course.

We may take the axioms in Kurt Gödel's *The Consistency of the Continuum Hypothesis* (1940) as the standard foundation of mathematics. The main results were announced a few years before (Gödel 1938). The details of the standard foundation are very difficult but a few glimses are included in the course. Also the details of higher-order logic are too difficult so the present course we consider only first-order logic. Although this is sufficient from at theoretical point of view it definitely would be better from a practical point of view to consider higher-order logic as well (it is probably not a good idea to skip first-order logic and jump to higher-order logic although it would have its benefits).

The main point is that mathematical logic is a relative new discipline and very tricky because the students have to learn to reason about reasoning, which most likely also explains why it took so many year to obtain the results. But the above results up to 1940 are only about the foundations and the limitations. They do not really consider how to use mathematical logic in practice, in particular, how to use a computer to make proofs using axioms and rules. In 1954 Martin Davis programmed the first computer to make a proof, namely that the sum of two even numbers is again an even number. Today computers can make proofs for which ordinary pen and paper proofs are not available (Hales *et al.* 2015).

In the 1930s Gerhard Gentzen and Stanisław Jaśkowski independently discovered natural deduction, which is a technical term referring to proofs with a changing set of assumptions. Many textbooks use natural deduction but it can be confusing to student. We have not used it before in the course but it is of course the core of NaDeA Natural Deduction Assistant (Villadsen *et al.* 2015). Here is a sample proof as displayed by NaDeA (browser screenshot):

```
1   Boole   [] ∃x.A(x)→(∀y.A(y))
2   Imp_E     [(∃x.A(x)→(∀y.A(y)))→⊥] ⊥
3   Assume      [(∃x.A(x)→(∀y.A(y)))→⊥] (∃x.A(x)→(∀y.A(y)))→⊥
4   Exi_I       [(∃x.A(x)→(∀y.A(y)))→⊥] ∃x.A(x)→(∀y.A(y))
5   Imp_I         [(∃x.A(x)→(∀y.A(y)))→⊥] A(c)→(∀x.A(x))
6   Uni_I           [A(c), (∃x.A(x)→(∀y.A(y)))→⊥] ∀x.A(x)
7   Boole             [A(c), (∃x.A(x)→(∀y.A(y)))→⊥] A(c')
8   Imp_E               [A(c')→⊥, A(c), (∃x.A(x)→(∀y.A(y)))→⊥] ⊥
9   Assume                [A(c')→⊥, A(c), (∃x.A(x)→(∀y.A(y)))→⊥] (∃x.A(x)→(∀y.A(y)))→⊥
10  Exi_I                 [A(c')→⊥, A(c), (∃x.A(x)→(∀y.A(y)))→⊥] ∃x.A(x)→(∀y.A(y))
11  Imp_I                   [A(c')→⊥, A(c), (∃x.A(x)→(∀y.A(y)))→⊥] A(c')→(∀x.A(x))
12  Boole                     [A(c'), A(c')→⊥, A(c), (∃x.A(x)→(∀y.A(y)))→⊥] ∀x.A(x)
13  Imp_E                       [(∀x.A(x))→⊥, A(c'), A(c')→⊥, A(c), (∃x.A(x)→(∀y.A(y)))→⊥] ⊥
14  Assume                        [(∀x.A(x))→⊥, A(c'), A(c')→⊥, A(c), (∃x.A(x)→(∀y.A(y)))→⊥] A(c')→⊥
15  Assume                        [(∀x.A(x))→⊥, A(c'), A(c')→⊥, A(c), (∃x.A(x)→(∀y.A(y)))→⊥] A(c')
16    *
```

The formula proved is the so-called *Drinker Paradox* (Smullyan 1978). The columns to the right with the line numbers and the rule names are not required but most helpful for students. One the other hand, the way the formulas is indented is crucial. It is not always the case that formulas are placed further and further to the right going towards higher line numbers. The special language with many symbols is also important. In a way the above sample proof using mathematical logic can be compared to a mathematical calculation like 10101*10101 = 102030201; it is something which all engineers can do using pen and paper but we rather use a computer or pocket calculator for the task.

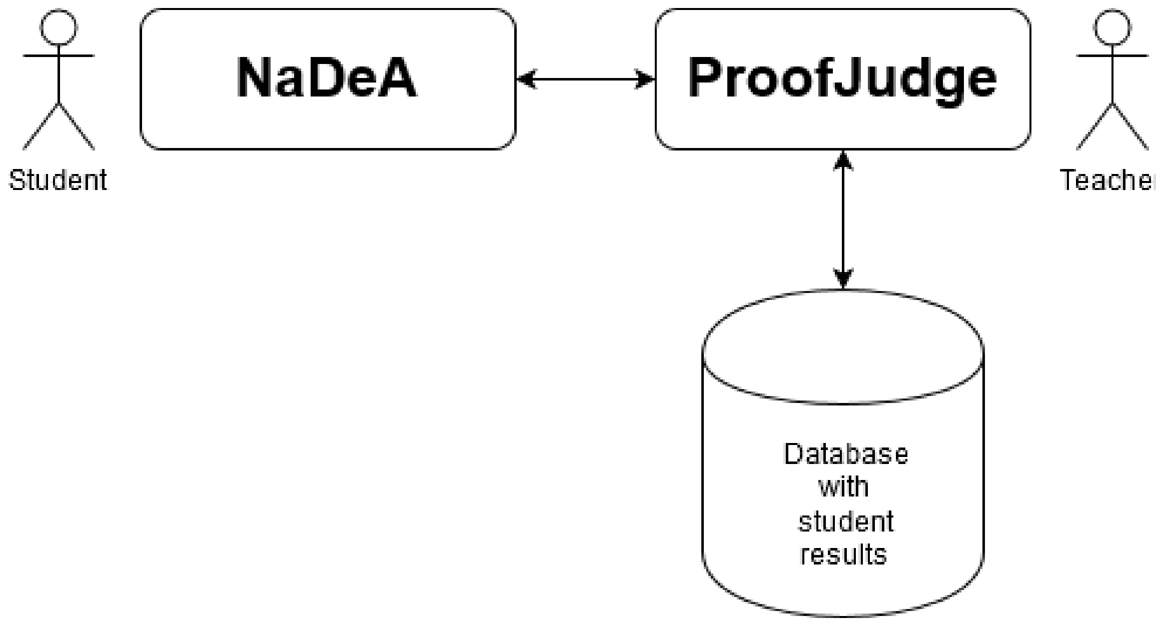
III DESIGN DECISIONS AND CONCLUSIONS

The course should prepare students for the use of proof assistants and NaDeA is an important step in this direction. The relevant tasks are as follows (Adams 2014): (1) the proof script must be executed to see that it produces the claimed formula as the final formula, (2) the definitions must be examined to see that the meaning of the final formula agrees with the common understanding, and (3) the proof assistant must be audited to make sure there is no foul play.

NaDeA (Natural Deduction Assistant) is a new tool for teaching logic based on natural deduction and with a formalization in the proof assistant Isabelle such that the usual informal descriptions can be avoided (Villadsen *et al.* 2015). ProofJudge is a separate component supporting student assignments and automatic feedback and/or grading via a database with student results.

Both tools work in a browser without any software installation and is open source software. It is expected to make the current course textbook optional (Ben-Ari 2012). Like for programming it is important to practice the syntax (Moth *et al.* 2011). Additionally NaDeA functions as a relatively gentle introduction to Isabelle which allows for interactive machine-checked proof and has the potential to fundamentally change how we build and trust critical software (Klein 2015).

We can illustrate the relationships between the student, NaDeA, ProofJudge and the teacher as follows:



We believe that automatic feedback on student assignments is going to be important for the motivation of the students and will free teaching assistant resources for more feedback on conceptual problems.

We find that the following requirements constitute the key ideals for any proof assistant. It should be:

– Easy to use.

– Clear and explicit in every detail of the proof.

– Based on a formalization that can be proved at least sound, but preferably also complete.

Based on this, we saw an opportunity to develop NaDeA which offers help for new users, but also serves to present an approach that is relevant to the advanced users.

ACKNOWLEDGEMENTS

Thanks to Alexander Birch Jensen and Anders Schlichtkrull for help with the development of NaDeA.

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BIOGRAPHICAL INFORMATION

Jørgen Villadsen is associate professor at DTU Compute (Algorithms, Logic and Graphs Section, Department of Applied Mathematics and Computer Science, Technical University of Denmark). Since 2007 Jørgen Villadsen has been programme director for the MSc in Computer Science and Engineering programme.

APPENDIX

We illustrate the central ideas using a simplified version of a small example from the DTU course 02156 Logical Systems and Logic Programming. A similar example is briefly discussed on the first page of *Logic: Techniques of Formal Reasoning* by Donald Kalish, Richard Montague and Gary Mar (Oxford University Press 1980). The following slides are from the course and use one of the proof systems in the course textbook. Currently the students do not use a tool for automated proof judging.

Consider the following argument in natural language:

If Joe studies then he passes the exam.

If Joe does not study then he has a good time.

If Joe does not pass the exam then he does not have a good time.

Therefore Joe passes the exam.

Consider the corresponding formulas in propositional logic (propositional calculus):

$s \to p$

$\neg s \to t$

$\neg p \to \neg t$

p

s corresponds to "studies", p corresponds to "passes the exam", and t corresponds to "has a good time"...

$$((s \to p) \land ((\neg s \to t) \land (\neg p \to \neg t))) \to p$$

Proof:

1.	$\vdash t, \neg t, \neg(s \to p), p$	Axiom
2.	$\vdash \neg\neg t, \neg t, \neg(s \to p), p$	$\alpha\neg$,1
3.	$\vdash \neg p, \neg t, \neg(s \to p), p$	Axiom
4.	$\vdash \neg t, \neg(\neg p \to \neg t), \neg(s \to p), p$	$\beta\!\to$,3,2
5.	$\vdash \neg p, t, \neg s, p$	Axiom
6.	$\vdash s, t, \neg s, p$	Axiom
7.	$\vdash t, \neg s, \neg(s \to p), p$	$\beta\!\to$,6,5
8.	$\vdash \neg\neg t, \neg s, \neg(s \to p), p$	$\alpha\neg$,7
9.	$\vdash \neg p, \neg s, \neg(s \to p), p$	Axiom
10.	$\vdash \neg s, \neg(\neg p \to \neg t), \neg(s \to p), p$	$\beta\!\to$,9,8
11.	$\vdash \neg(\neg s \to t), \neg(\neg p \to \neg t), \neg(s \to p), p$	$\beta\!\to$,10,4
12.	$\vdash \neg(s \to p), \neg((\neg s \to t) \land (\neg p \to \neg t)), p$	$\alpha\land$,11
13.	$\vdash \neg((s \to p) \land ((\neg s \to t) \land (\neg p \to \neg t))), p$	$\alpha\land$,12
14.	$\vdash ((s \to p) \land ((\neg s \to t) \land (\neg p \to \neg t))) \to p$	$\alpha\!\to$,13

We provide a simplified version of the example. We consider the following logical formulas for the natural language sentences where the minus sign is used for the “not” construction and the arrow is used for the “if … then” construction:

S → P   If Joe studies then he passes the exam.
-S → T   If Joe does not study then he has a good time.
-P → -T   If Joe does not pass the exam then he does not have a good time.
P   Joe passes the exam.

The goal is to show that the final sentence follows logically from the 3 conditional sentences above. This must be shown without appealing to intuition because we want to automate the reasoning.

Intuitively we can reason as follows. Assume -P (we will show that this is impossible, so therefore P). Remember that -P means “not” P. Then from S → P we have -S because otherwise (that is S) we would have P (and we already assumed -P). And then from -S and -S → T we have T. But from -P and -P → -T we have -T. So both T and -T, which is impossible, hence we do not have -P, and therefore we have P.

This intuitive reasoning is not immediately suitable for automation. A format more suitable for automation is the following formal proof:

1.1   -(S → P) | -(-S → T) | -(-P → -T) | P
  2.1   S | -(-S → T) | -(-P → -T) | P
    3.1   S | -S | -(-P → -T) | P
    3.2   S | -T | -(-P → -T) | P
      4.1   S | -T | -P | P
      4.2   S | -T | T | P
  2.2   -P | -(-S → T) | -(-P → -T) | P

The line numbers 1.1, 2.1, 2.2, … are not part of the proof as such. The bar | is used to separate alternatives. Hence line 1.1 states that either one of the 3 conditional sentences must be false (note the added minus signs) or the conclusion (P) must be true. In lines 2.1 and 2.2 the requirements for the falsehood of S → P are examined, namely that S is true (2.1) and P is false, that is, -P is true (2.2). Analogously for lines 3.1 and 3.2 (considering 2.1) and for lines 4.1 and 4.2 (considering 3.2). In all relevant cases (2.2, 3.1, 4.1 and 4.2) we find a tautology (like P or -P for 2.2):

2.2   -P | P
3.1   S | -S
4.1   -P | P
4.2   -T | T

So the formal proof is correct and appropriate feedback can be provided to the student by ProofJudge.

Interactive videos with embedded questions

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ABSTRACT
Keywords - online videos, flipped classroom, learning.

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

The goal with interactive videos with embedded questions is to increase the learning gain students get from watching online videos. The rationale for such videos is based on ideas about active learning and the flipped classroom.

An “active learning” lecture, in which student understanding is gauged at several times during the lecture, seems to raise the learning gain, compared to a passive lecture, where the instructor presents the material (Meltzer 2002). Peer instruction is one approach to active learning, where the students are given conceptual questions and can answer them using a student response system; such that the lecturer can act on the given answers, either by presenting the material once again with a different perspective or let the students discuss the question in small groups (Crouch 2001).

To maximize the outcome of the limited class time that is available in many teaching situations, one approach is to flip the classroom, such that students watch recorded lectures at home and work on exercises in the class. One benefit of recorded lectures is that a student can pause and replay videos as needed, but the main drawback is that it is difficult (if at possible at all) to use active learning approaches in the videos.

The question is how video based lecturing can benefit from the ideas about active learning to increase the learning gain. My approach is to pause the video at certain locations and then pose a question to the student. The purpose with the question is to let the student use the knowledge that was presented in the video. This sequence of presentation followed by activation is expected to increase the learning gain significantly.

The setup consists of videos uploaded to youtube and a customized online video player that can show the questions and check for correctness. The online video player is being developed as part of an e-learning project at the University of Southern Denmark and will be released as open source software. A demonstration is available at http://tekvideo.sdu.dk/t/henrikmidtiby/Demo.

Come and join a discussion on how to increase student gain from online videos and get a demonstration of the online video player with embedded questions.

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Active students with the use of IF-AT

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ABSTRACT
Lectures are an easy way to transfer information to a large population of students. The downside is that lectures induce passive learning. The opposite; active learning is therefore relevant to implement. Engagement of students is a key stone in active learning. IF-AT (Immediate Feedback Assessment Technique) is an easy-to-use and useful technique to engage students even in large classes. Facilitating of an activating, cooperative and "deeper" learning is present thus stimulating an enhanced learning (Millis, 2015). Multiple choice questions and answers are connected to a scratch card providing the immediate feedback.

Keywords:
Facilitating Learning in large classes, IF-AT, Scratch Cards

INTRODUCTION

The objective is to change from a more passive and traditional information transfer in lectures to an environment where the students become more active in and out-of class. IF-AT is an activating multiple choice question technique providing immediately feedback about the accuracy of the answer to each question (Enterprises, 2015). Multiple choice questions and answers are connected to a scratch card providing the immediate feedback. Additionally, it is possible to add on a spirit of competitiveness - extra stimulating for some. Active learning can bring higher grads and lower failure rate (Freeman, et al., 2014). One way to use this technique is presented: The students are presented with questions and possible answers related to relevant topic. Each student work with the questions individually. After a fixed amount of time, the students are arranged in groups. Each question is then discussed within the group and they must all together decide which answer is correct - then scratch. Immediate the feedback is either affirmative (showing a star) or corrective (showing a blank). If the feedback is corrective, the group must rethink and work with the subject/question and identifying the next possible correct answer until the correct is discovered. The outcome is to enhance active, cooperative and "deeper" learning while the students receive immediate feedback.

Session type: Active Poster

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Online learning guided tour in substation design using Blackboard

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ABSTRACT

Keywords – STREAM model, SAMR model, online learning, Blackboard.

This poster presents an experience with a learning path design using blackboard as stepwise integrative tools for learning activities which shows effectiveness of the online learning design in “augmentation level” as per revised SAMR model (Mikkel Godsk 2014).The objective of the learning path design was to prepare an instruction and procedure for doing the project of “Substation and Switchgear” course.It is a course for the bachelor students in 6th and 7th semester at department of electrical energy (power) engineering at Aarhus University. It is a 5 ECTS, 7weeks course with 20-25 students. The course is combination of lectures and problem solving exercises in the form of a project including different parts covering the curriculum. The challenge I faced was about the lack of a guideline for managing students to do the project which had been designed to make connection between lecture theory and also out of class activities with within class activities as per STREAM model (Mikkel Godsk 2014).

Blackboard has been used to design learning path comprising activate content/curriculum, having mechanisms for feedback and visible communication. Each learning path covered description of activities relevant to each step of designing the substation. These activities have been supported by relevant materials, sample examples and a few PowerPoint including recorded sound and videos. Blackboard helped to move some basic instructions to the web and leave more time for in depth questions or knowledge in the lectures/ theoretical exercises. It has also given opportunity to have reflection to each group work at each step by having relevant rubrics for each activity evaluation and students benefit from peer review and sharing knowledge which enhanced their learning even they have not been involved in the details of part of the project. It helped students make their own practical experience with project design in an active and social practice. (Grainne Conole, 2008).

Formative assessment has been used to evaluate each group activities and performances based on the usage of the each learning paths, the level of their contributions on each learning path and the quality of the delivered report at each steps which was conditional for participation in the final oral exam. The student’s feedback about usefulness of learning path and stepwise procedure for doing a project was also satisfactory; however, in particular cases, it has been requested for better explanation of each activity and adding more videos and Screencast example calculations.

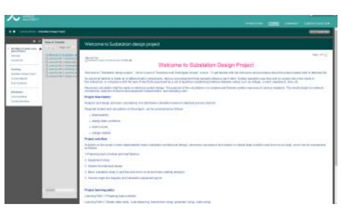

Figure 1: Platform using Blackboard

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From lectures to interactive blended learning: Two hands-on experiences

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ABSTRACT
This study describes how we changed classical lectures into interactive learning, combining online materials with different physical ways of interacting. The first case is a local course, taught at the Aalborg University campus in Aalborg, whereas the second case regards a course offered between 7 different European universities. Thus, the possibilities for physical interaction are very different. In both cases, the approach was positively received by the students. However, in the first case it turned out that the students were using the material differently than initially designed for: In particular, most students preferred to work on the quizzes in groups (with videos and literature as supporting elements). In this way, the material turned out to be a good facilitator for peer learning, and in our view more "active learning" than initially thought. Experiences from the first case was used to change the design in the second.

Keywords - interactive teaching material, blended learning, online learning material, active learning.

I INTRODUCTION

One of the main challenges the universities are meeting these years is the increasing amount of students with different backgrounds. This is driven by a number of factors, including:

- In general, a larger number of students are pursuing higher education, leading to increasing diversity in student's motivation and learning styles.
- For certain technical fields, such as electrical engineering, there is a high labour market demand for the candidates, while the number of students interested in the field is decreasing. This is leading to a situation where the universities need to contain a wider group of students with different goals and learning styles.
- Increasing mobility among students, where it is becoming more common to take one or more semesters abroad, and/or combine bachelor and master studies in more different ways. Even if efforts are made to ensure all students have prerequisites for all courses, this does lead to a situation where different students have more diverse backgrounds and experiences than before.

These challenges call for teaching methods different from the traditional classroom teaching, but also for methods which allow a more personalised approach in terms of both form and content.

In addition to these general challenges and observations, which are in line with those described in (European Commission, 2011) we identified a potential for improving student's outcomes for a particular course, a 5th semesters course on "Communication in Electronic Systems", which is a mandatory course at the B.Sc. education in Electronics and IT at Aalborg University. Both ongoing discussions with students and exam results revealed a potential for increasing the student's outcome of the teaching, and thus the main motivation was to better help the students to fulfil the learning objectives of the course (and consequently obtain a better knowledge of the topics covered in the course). Increasing the fraction of students that would pass was also a supporting factor, together with increasing the general interest for the topic. With this as a main motivation, we re-developed the part of this course that focused on computer networks.

In this paper we describe how we re-implemented the course based on blended learning, through the creation of video lectures and interactive online material in combination with face2face workshops and seminars. We discuss our observations and experiences with this teaching format. Moreover, we describe how the same methodologies were later applied in an international course, and the experiences collected in this setting.

The paper is organised as follows. Section II presents how the material was implemented in the 5th semester course. Section III the implementation in the international course. Section IV summarizes our experiences, conclusions, and recommendations for future works.

II Case 1: 5th semester course

The idea

The basic idea was to convert each classical lecture (typically 2x45 minutes lecture + 2 hours of problem solving in groups) into an interactive lecture module. For each module, the student was expected to go through the following steps:

- Study the literature specified and watch 1-2 video lectures covering the material.
- Take an interactive quiz generated by us in Moodle. Based on the answers provided, the student receives instant feedback for both correct and incorrect answers, with suggestions as to which literature and videos to study again.
- The student can then study more and re-take the quiz, with no limits as to when and how many times the quiz can be done. The quizzes were designed to cover the learning objectives of each module, so when the student would be able to correctly answer all quizzes he would also be well prepared for the final course exam.
- The students were asked to finish each quiz by a specific date, usually two days before the workshop of each module.
- Based on quiz results (which could be accessed by teachers) and student feedback by email, a face2face workshop was designed inspired by the concept of just-in-time learning (Novak et. al., 1999). The workshop was scheduled for 4 hours and usually started with 30-60 minutes of lecture (a combination of theory and going through examples), followed by problem solving in groups with teacher assistance available. Initially it was concluded by a joint Q&A session, but this was eventually skipped since all questions were answered during the problem solving. Both lecture content and problems were based on student feedback and quiz results.

Implementation issues

It was a clear aim to establish a clear alignment between learning objectives, topics covered, teaching methods, and the final exam. This was done by establishing clear learning objectives for each of the interactive modules, so that the modules all together would meet the learning objectives of the course (which were not changed compared to the previous versions). Based on the learning objectives for each module, the quizzes were created to ensure that the topics were well covered. With quiz and learning objectives for each module in place, the lecture was designed to cover these aspects, and after this ready to be recorded. Also, during this process, the exam questions were defined to ensure that no topics were overlooked in the module quizzes and lectures. The process requires planning well ahead of course start. The students, on the other hand, could also clearly see this – in fact, the learning objectives for each module was explicitly presented in the beginning of the video of each module.

In order to make slides as well as lectures available in a high quality (audio and video), the video lectures were recorded in a dedicated video studio which was kindly made available to us by the University of Stavanger, Norway. The recordings were made in two "tracks", so the lecturer and power point slides are separated in the recordings. This makes it possible for the student to control how to watch the lecturer and the slides at the same time. Another advantage of the professional setting is that slides are numbered, so it is possible to "jump" in the video stream, either from slide to slide, or by looking for a particular slide. A search function can also be made available for the students, but it was not implemented in our setting since it required additional work to indicate key words for each slide.

The quizzes were created in Moodle, which is the teaching platform used at Aalborg University. It turned out to be quite a strong tool, with different ways of asking questions and defining answers, even when immediate feedback is offered to the student. In addition to classical multiple choice, this includes matching questions (matching multiple statements with possible answers), answers in terms of text (asking the student to provide for example a word), and answers in terms of numbers. Asking all questions on this type, without allowing for answers containing text, explanations, drawings, etc. was a challenge, but especially using the ability to check the correctness of numbers made it possible to test all learning objectives in a satisfactory way.

On the positive side, Moodle allows to give different feedback to students depending on which answers they are providing. Not only does it allow for providing different feedback for correct and wrong answers, but answers that indicate e.g. common misunderstandings or misconceptions can initiate particularly helpful feedback. Due to time constraints, in this case the students were just informed if their answer was correct (and otherwise what would be the correct answer), and in case of both wrong and correct answers they were pointed to information sources (e.g.. specific book pages and specific slides) for more information. Initially the idea was to do this only for wrong answers, but there was no reason not to advice students with correct answers, who for some reason did not feel completely comfortable with the question.

It should be noted that the final exam is still "with pen and paper". Despite the questions being formulated in similar ways to what the students meet in the course, they are allowed to elaborate or explain their answers, making it possible to award points to partially correct answers which would be difficult based on the electronic questionnaires.

Experiences during the course

The first observation was that the students expressed a positive attitude to the approach, so the initiative was well received. During the first modules, almost all students came well prepared, had done the quiz, and also had handed in questions/suggestions that could fill out the workshop. The workshop would usually be going through additional examples on the blackboard, followed by additional (and more traditional) problem solving in groups. The students generally expressed a high satisfaction with the course, and the fact that they could study the material in their own pace. Some did realise a main weakness in the videos, namely the lack of possibility to ask questions and get answer on-the-fly, and thus it is possible to get stuck halfway through a lecture. With classical lectures, it is possible to ask such questions during the lecture (even though not everyone is taking advantage of the option).

After the first modules, the attitude slightly changed, and fewer students would show up well prepared. With less topics for the workshops, the students instead spend the workshop timeslot on going through videos and quizzes in groups, with teachers passing around with help and guidance. While different than designed, this appeared to be a quite effective way of learning, and the students became quite active in the process: They would discuss both questions and answers, study additional material, use the blackboard, and explain and discuss concepts among each other. Also, this solved the above mentioned problem of missing the opportunity to ask questions during lectures.

Many students also expressed that they were particularly happy about having the material available for exam (or even re-exam) studies. Making a strict comparison of exam results compared to previous years was not done though. Partly because the exam questions were completely re-formulated and this not comparable, and partly since it is a different year of students, to different results would be expected in any case.

Observations and learning points

The main objective was to better help the students fulfill the learning objectives of the course, and obtain a better knowledge of the topics covered by the course. Based on our observations, discussions with the students, feedback during semester group meetings, and exam results it is our clear impression that this objective was reached. However, we did not conduct a scientific study, and we are aware that student evaluations, feedback and exam results might also reflect that students differ from year to year. In the following year we did similar observations, though, which together with the student feedback supports our conclusion that the teaching methods have improved the learning outcome.

While the feedback was generally positive, a number of observations and learning points were done during both first and subsequent years.

Based on a questionnaire distributed to the students, as well as oral feedback from students during workshops and semester meetings, it was very well received. However, it turned out to be sometimes used slightly different than designed for. This is not a problem, and in fact it worked fine with the students using the material for more collaborative learning during the workshop time. However, making the video lectures shorter would make them even more useful in both self-study and collaborative scenarios, so our recommendation would be to have shorter video clips (5-10 minutes) with quizzes in between each. This would make the learner more active, and consolidate the knowledge before moving on.

We also observed that having material available online is a big help for students in other semesters, who need the knowledge – for example students from abroad who are preparing for a new semester, or students who need the knowledge for e.g. project work. Being able to simply provide them a link and an offer of help can be a big help, without too much effort. In fact, the module has also been used for lifelong learning initiatives, where part time students from industry can refresh their knowledge before attending e.g. master educations.

One challenge is also that it is hard to make slight improvements. Changing or adding material often leads to revision of both slides, videos and quizzes, which is cumbersome, and especially the videos require lot of work in case a new recording is needed. Using shorter videos would help on this issue, especially if video recording equipment could be made available locally.

III Case 2: International course module

The Colibri course

Colibri (Colibri, 2015) is an international project supported by Erasmus+ in the framework of Strategic Partnerships. 7 universities together with 2 companies and a national documentation center, are together developing a course based on blended learning, where students will work together in interdisciplinary and international teams on solving actual problems from real companies. The overall aim of the project is to test new and innovative teaching methods, with particular focus on internationalisation, personalization, and the use of ICT tools. With a focus on these aspects, the teaching methods to be tested are defined from year to year in the beginning of the cycle as described below.

The Colibri course will run each spring in 2015, 2016 and 2017, each year followed by four students from each of the 7 universities involved. The overall topic of the course is "Future Internet Opportunities", and the students come with different backgrounds within e.g. telecommunications, computer engineering, business informatics, and entrepreneurship. The course accounts for 5 ECTS, corresponding to around 150 hours of work for each student.

Each year, it is organised according to the following plan:

- Around March 1 a virtual kick-off introduces the students to the learning objectives, the course, and the methods used.
- From March 1 and until mid April the students follow course modules each being offered at 2-3 levels (each students select which ones to follow at which levels).
- Mid April a physical seminar (midway seminar) is held, where the course modules are finished, and the project groups and project problems announced.
- From Mid April until Mid July the students are working together virtually on the project, inspired by the Aalborg PBL Model (Kolmos et. al., 2004).
- A final seminar (project seminar) is then held in mid July, allowing the students to finish the project work, prepare project presentations, and eventually attend an exam.

There is no separate exam for the modules, but the students are expected to use relevant material from the modules in the project, and should be able to demonstrate this knowledge during the examination. The examination is based on a presentation of the project (as a group), followed by a discussion session that also includes individual questions.

In this paper, we will describe the design of the course modules, with particular focus on the module on network security for which AAU is responsible.

The idea

In order to be consistent and not confuse the students too much, the teaching material form used in the Colibri modules is defined in the beginning of each round of Colibri. This is done in terms of a number of "teaching tools" that can be used, but it is not required that all modules make use of all the available tools.

Our Colibri module on network security is offered at two levels: Introductory level, to be followed by all students, and basic level, to be followed only by students who selected the topic. Since the student workload of the introductory part is only 1 hour we will focus mainly on the basic part, which account for a student workload of 5 hours.

The form of the module is inspired by our previous experiences from the 5th semester course described in case 1. Thus, the module is composed by the following elements:

- An introductory test, where the student can test if he has the prerequisites to follow the course. If this is not the case, he is suggested material that can help him get to the right level – some of this is provided by us, and some is links to external sources.
- Video lectures with a duration of 5-10 minutes. The introductory part contains 3 such lectures, whereas the basic part contains 4.

- Quizzes in Module for self-assessment. In addition to a quiz after each lecture, there is also a "final" quiz after both introductory and basic parts. This also serves as a midway-exam, since the students are expected to successfully finish this before attending the midway seminar.
- Moreover, some individual assigments are introduced as part of the basic course.
- Given that the students are spread over different physical locations, a Moodle forum is introduced instead of the face2face workshops.
- One hour was set aside during the midway seminar to finish the module, mainly for on-demand topics and questions.
- In addition to finalising each module, a panel discussion was organized with all module responsibles being present in the panel. The purpose was to help the students binding the content of different modules together, and to see how each module would fit into a bigger picture.

Other modules explored also other ways of using peer learning (e.g. with joint exercises in groups that had to collaborate across distance, and/or peer assessment of tasks).

A full overview of Colibri can be found in (Lopez, 2015).

Implementation issues

The implementation was done largely similar to the previous course. Even if there was no specific examination of the module, there were clear learning objectives, and these were translated into learning objectives of each session of video+quiz. The recordings were done in a less professional setting due to time constraints, but again Moodle was used as a platform for quizzes and forum discussions.
As part of Colibri, all teaching materials were made publicly available. For this reason the videos were published on Youtube, and all material (including all slides) had to be done without the use of copyrighted material.

Experiences during the course

The first experience was during the kick-off meeting. We experienced how difficult it is to run a video conference call between participants in 10 different locations, especially when many are not used to multi partner video meetings. This confirmed our initial expectation, that such sessions have to be very carefully thought through.

For us as lecturers, it felt very different to give a course for students you have never met, and without the possibility to physically meet until the end of the course. While it is possible to track the students progress in Moodle, it does not provide the same feeling for how the students are doing and what they need. Based on what we saw in other modules, it is our experience that it was important to define exactly what was expected from the students, something that was supported by the use of Moodle quizzes.

When discussing the teaching material with the students during the midway seminar they also expressed that the form with videos and quizzes worked well, and they recognized that it allows students with different backgrounds to study in different speeds.

During the midway seminar, the panel discussion worked out to be more valuable and lively than the session arranged for each module – for the security module, it was clear that most students had understood the content, something that also showed in the results of the last quiz.

Otherwise the module was well received. Afterwards it was evaluated through a questionnaire filled out by all students with the following results (respondents are those who followed the basic module, in total 17 students). All questions are evaluated on a scale of 1-5 (1: very inefficient, 2: inefficient, 3: neither efficient nor inefficient, 4: efficient, and 5: very efficient)

- With respect to how efficient the overall learning experience was, 12% rated as efficient and 82% as very efficient. One student did not answer.
- The video lectures were rated as efficient by 24% and very efficient by 77%.
- The questions/quiz material was rated as either efficient nor inefficient by 6%, efficient by 18% and very efficient by 71%
- The Q&A forum was rated as inefficient by 6%, neither efficient nor inefficient by 29%, efficient by 18%, very efficient by 12%, and 35% did not reply (or did not use it).

The lower rater for the Q&A forum is not surprising, since it was not very clear how the students were expected to use it, other than asking any questions that could come up during the course. We believe that the scores would have been higher if it was used in a more structured and well defined way, closely linked to the learning objectives, such as how the videos and quizzes were used.

In addition to the evaluation of this specific module, we asked the students how they perceived the teaching methods used in the Colibri course as a whole, compared to traditional teaching methods. These results will be described and analysed in future articles, but includes the following answers (all from a scale 1-5, where 1 is lowest and 5 is highest):

- Compared to your previous university experiences, please assess the following: To what extent do the teaching methods used in Colibri increase the quality of the learning offer? (average 3.7, with 63% of the students answering 4 or 5).
- Compared to your previous university experiences, please assess the: To what extent do the teaching methods used in Colibri increase the relevance of the learning offer? (average 3.7, with 70% of the students answering 4 or 5).
- Compared to your previous university experiences, please assess the following: To what extent do the teaching methods used in Colibri increase the labour market relevance of learning provisions and qualifications? (average 4.0, with 74% of the students answering 4 or 5).

It should be noted that this evaluation covers both course modules and project work, and that the project work was generally very well received by the students.

Observations and learning points

First of all, the material generally worked out well and was well received by the students. The adjustment of the form into the use of smaller videos worked out well.

A learning point is that, especially when there is limited or no possibility for face2face interaction, it is important to be very clear when communicating instructions and expectations to the students. However, even with this made clear, we still were missing feedback from the students. If and how this can be done is a question for further exploration, but maybe a beginning can be a more systematic tracking of progress than what is possible in the current module. Another approach could be to use the forum in a more systematic way, but we are unsure how this can be done in a practical way.

An aspect not related to each single module also became clear during Colibri, since each student had to follow a number of different modules: The need for some level of homogeneity. Even if all modules were based on the same platform, and in principle using the same tools, it could become confusing for the students to follow the different modules in parallel. This does not matter so much when introducing new methods in a single course, and we do not believe that "one size fits all". But at least it is something to keep in mind when implementing new teaching methods on a larger scale.

We would also say that it is important to carefully consider how the very limited face2face time is spent in the best possible way, especially in a setting where neither students nor teachers know each other well. The panel discussions worked out well, and it could be interesting to explore more ways of “active interaction”, where the different backgrounds and perspectives of students can actually come into play – and more so than by solving mono disciplinary problems together. We are aware that this of course depends on which learning objectives are formulated.

IV Conclusions

In this paper we have described how classical lectures have been change into interactive modules, based on the combination of online materials with different ways of physical and virtual interaction. In particularly, we have presented two case studies – one from a local course in Aalborg University, and one from an international course shared between 7 different European universities.

The overall idea has been to combine video lectures and online quizzes with immediate response with on-time lectures (in the local case) or a seminar at the end of the module (in the international case). A Q&A forum was also made available in both cases, but not very widely used. Overall, the material has been well received by the students, and it is our observation that it has contributed to increase both learning outcome and student’s motivation and interest.

It is our conclusion that for success it is important to have a clear alignment between learning objectives, video material, quizzes, and exam/evaluation. Also, clear instructions on how to use the material is needed especially in the international case where there is no or very little interaction between students and teachers.

Our future work can be divided into three parts.

The international Colibri course will be further developed through 2016 and 2017. For the course module, we would like to explore how we can integrate more interaction between students, and between students and teachers, while maintaining coherence between learning objectives, teaching material, and examination. Also, it is important to keep it very clear for the students what we expect them to do, and when they have fulfilled these expectations. We will also explore further the individualization, and how the pre-test and pre-material can be used. In particular, students who already are partially familiar with the course could be recommended only the parts that they miss. This would be very useful in Colibri, since the participants come with different backgrounds, but also beyond.

For the local course, the plan is to redesign the course, so the current modules are split into sub modules with shorter videos and quizzes, while each module should still have a final quiz. Moreover, we would like to increase the amount of questions in the quiz bank, so students can re-take the quizzes with new questions covering the same learning objectives. As this is quite work intensive, it could be interesting to co-create content with other universities while still maintaining the face2face activities as local activities. As the course is quite a fundamental course, other universities do have courses with similar content and learning objectives.

For the general study, we would like to work more systematically with evaluation of how well new teaching methods work. For this reason, we are currently establishing collaboration between our department and the Aalborg UNESCO Centre for Problem Based Learning (UNESCO, 2015).

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Active learners in Sustainable electronics and IT

-poster presentation

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Keyword: Active learning, problem based, teamwork, sustainability, lower power, wireless embedded system, embedded software protocols

ABSTRACT
This poster-presentation is about active learning in a course sustainable wireless electronics and it. Active learning understood as practical lab-exercises and a team chosen project.

INTRODUCTION

This poster will present how I activate the students in an elective course SUSIE (62562– 10 ECTS ref 1) and student's results. Students studying Electronics and IT/software are much focused on the technology rather than looking at environmental impact. Therefore we have integrated design for low energy and resources in the curriculum. Further, to motivate the students we let them build/program an embedded system from sensor to cloud (internet of things) which should have a purpose of bringing awareness about the way we use a house/living room as well bringing a better indoor climate. The course has been offered for the past 2½ years to Electronics and IT Bachelor of Engineering students at DTU Diplom former IHK.

Project work

Finally, team based project work is undertaken with the purpose of using all the topics and lab-exercises from the classes in solving a self-chosen problem during 4weeks of each 8 hour: *"Chose a problem domain for which it is relevant to monitor environmental data and controlling actuators, e.g. in a home, at Campus Ballerup, a green house, plant control, electrical vehicle, etc."* –*"One of the wireless nodes should be powered by a renewable energy source"*. The poster will present examples on projects and labs and outline what is required to run such a course. The website http://www.sustainableelectronicit.org/ presents some of the student's projects.

Relations to other courses

The poster will also short show how students from this course are inspired to cooperate with students enrolled in another elective course about a Sustainable development and design (SDTU). The students are then able to apply their knowledge from the SUSIE course in the cross disciplinary course, building prototypes for building control and learning about energy screening and regulations and standards for energy consumption in buildings.

Outcome

By participating in this poster presentation you will get ideas about how students are a motivated by defining their own problem and project and how the curriculum is designed.

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