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Developing requisite motivation in engineering studies

A study on a master and bachelor program in electronic engineering at Uppsala University

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DEVELOPING REQUISITE MOTIVATION IN ENGINEERING STUDIES

A STUDY ON A MASTER AND BACHELOR PROGRAM IN ELECTRONIC ENGINEERING AT UPPSALA UNIVERSITY

BY
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Talk to me.... and I will forget
Show me.... and I will remember
Involve me.... and I will understand
Step back.... and I will act
Confucius

Kjell Staffas

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A six year old girl is sitting in the back of a drawing lesson. She hardly ever pays attention besides drawing class.

The teacher walks down to her and asks: What are you drawing?

The girl answers: I'm drawing a picture of God. But nobody knows how God looks like, the teacher replies.

They will in a minute, the girl answered!

Abstract

This thesis is a result from a frustrated teacher at a larger research-intensive University. Under almost ten years the teaching got from being a pure joy to disappointed and almost ridiculously demanding students on what my role in their learning process was. The first couple of years I was a very popular lecturer and enjoyed my practice and the students performed well. But the passing rate sank and many of them did not pass the courses even on the rest exams, so there were lots of students locked in the system of unfinished courses and the frustration was mutual between the students and me as their course coordinator. Therefore, I was guided to other teaching methods and came among others in contact with problem based learning, Kolb's experiential learning and other more student active learning methods. Although the students enjoyed my new approach of teaching the results did not improve significantly and my curiosity increased even more on how to help the students to learn what was necessary to pass the exam.

My investigations have been focused on what motivates the students to work harder and know how and what to study to learn electronics that is experienced to be an abstract and quite mathematical demanding subject. One important corner stone of my inquiries is to focus on the intrinsic motivation of the students, visualized as all the offered learning environments beside the exam shall be voluntary for the students: they will participate because they want to, not because it is necessary for them to be there. The process of inquiries is done in good spirit of the Kolb's theory on learning by experience, which basically is just what Dewey, Lewin and Piaget already have presented in their work prior to Kolb. The first step was basically to aim for more communication with the students, primarily in the lecture hall. This was done by introducing flipped classroom and short lectures online inspired by micro teaching. From there four categories of students were spotted and the future focus was mainly on the ones that struggled to pass the course. Not surprisingly the students that normally passed increased their knowledge and got better grades, probably because they could benefit partly from the developed practices, and partly from the fact that they became a kind of tutors for their fellow classmates.

Still the results was not significantly better so the next step was to focus on how the content was presented and in good spirit of Baltzis & Koukias findings, the simulation of circuits to help understand the concepts (and procedures in some cases) became a more central part of

the teaching material. Based on the revised taxonomy of Benjamin Bloom and Carstensen & Bernhard's holistic approach, a method proceeded from the cognitive levels of understand and apply to learn facts, procedures and concepts was tested in a smaller scale. The result was really promising and the results are presented in chapter 9.

As a summary teaching in higher education has changed and other methods are needed, probably because the number of students has increased and that the general standard of the average student has dropped in the western European countries (a trend shown in PISA tests and similar) in term of mathematics and science knowledge from secondary school, especially in Sweden. The method this thesis present is based on the revised taxonomy of Bloom and more focus on students working with "real problems" mainly with simulators instead of wasting time on boring and ineffective lectures. Further studies will focus on this kind of teaching in a larger scale, and an extensive analyze of the concept "teacher" as an institution rather than merely a person that informs and explains how to understand and solve abstract problems.

Abstrakt

Denne afhandling er lavet af en frustreret lærer på et større forskningsintensivt universitet. Gennem næsten ti år forandrede undervisningen sig fra at være en ren fornøjelse til et møde med skuffede og næsten latterligt krævende studerende der ikke forstod hvad min rolle i deres læreproces var. De første par år var jeg en meget populær forelæser og nød min praksis og de studerende klarede sig godt. Men beståprocenten faldt, og mange af de studerende bestod ikke engang til reeksamen, så der var masser af studerende fastlåst i systemet med uafsluttede kurser og frustrationen var gensidig mellem de studerende og mig som deres kursus koordinator. Derfor blev jeg guidet til andre undervisningsmetoder og kom blandt andet i kontakt med problembaseret læring, Kolbs erfaringsbaseret læring og andre mere studenteraktiverende læringsmetoder. Selvom de studerende nød min nye tilgang til undervisning, var resultaterne ikke signifikant forbedret og min nysgerrighed steg endnu mere i forhold til, hvordan man kan hjælpe de studerende til at lære, hvad der var nødvendigt for at bestå eksamen. Mine undersøgelser er fokuseret på, hvad der motiverer de studerende til at arbejde hårdere, hvordan og hvad man skal studere for at lære elektronik, der opleves som et abstrakt og meget matematisk krævende emne. En vigtig hjørnesten i mine undersøgelser er at fokusere på de studerendes indre motivation og visualisere alle de tilbudte læringsmiljøer ved siden af eksamen: de deltager, fordi de vil, ikke fordi de skal. Processen med henvendelser sker i god ånd med Kolbs teori om læring gennem erfaring, som dybest set er det samme Dewey, Lewin og Piaget allerede har præsenteret i deres arbejde før Kolb. Det første skridt var dybest set at stræbe efter mere kommunikation med de studerende, primært i auditoriet. Dette blev gjort ved at indføre et omvendt klasseværelset og korte foredrag online inspireret af mikroundervisning. Derfra spottes fire kategorier af studerende og det fremtidige fokus var primært på dem, der kæmpede for at bestå kurset. Ikke overraskende har de studerende, der også normalt bestod, øget deres viden og fik bedre karakterer, sandsynligvis fordi de kunne drage fordel både fra de udviklede praksis, og fra det faktum, at de blev en slags vejledere for deres klassekammerater. Resultaterne var dog stadig ikke signifikant bedre end tidligere, så det næste skridt var at fokusere på, hvordan indholdet blev præsenteret. I tråd med Baltzis og Koukias resultater om simulering af kredsløb for at hjælpe med at forstå de begreber (og procedurer i nogle tilfælde) blev disse en mere central del af undervisningsmaterialet. Baseret på den reviderede taksonomi af Benjamin Bloom samt Carstensen og Bernhards

holistiske tilgang, blev en metode udviklet der involverede de kognitive niveauer af forstå og anvende til at lære fakta, procedurer og koncepter testet i mindre skala. Resultatet var virkelig lovende, og resultaterne er præsenteret i kapitel 9. Til afrunding: undervisning på de videregående uddannelser har ændret sig, og der er behov for andre metoder, sandsynligvis fordi antallet af studerende er steget og det generelle niveau af den gennemsnitlige studerende er faldet i de vesteuropæiske lande (en tendens, der er vist i PISA tests og lignende) særligt i forhold til matematisk og naturvidenskabelig viden fra gymnasiet, især i Sverige. I denne afhandling er metoden baseret på den reviderede taksonomi af Bloom samt mere fokus på studerende, der arbejder med "rigtige problemer" hovedsageligt med simulatorer i stedet for at spilde tid på "kedelige" og ineffektive foredrag. Yderligere undersøgelser vil fokusere på denne form for undervisning i en større skala, en der vil ske en omfattende analyse af begrebet "lærer" som institution snarere end blot en person, der informerer og forklarer, hvordan man forstår og løser abstrakte problemer.

Acknowledgements

This thesis started with a rumor that the head of the department of engineering sciences needed a teacher for some future technology teachers. So I knocked on Mikael Jonsson's door and asked if there was something for the rumor. He confirmed and I said I was the man and he bought it. But the condition for arranging a course for these students was that I could improve my own knowledge of the field. He kindly offered me 30% of full time and proposed that I would aim for at least a licentiate thesis on that time. I got three years guaranteed and, despite the responsibility of a large number of employees, he has been very supportive and encouraging through the whole process.

I have actually not a research team, fellow researchers and PhDs' that I have studied along, so the entire work is between me and my tutors of Aalborg University. But I like to thank Anette Kolmos for a great welcoming and good support when I needed. Her knowledge is nothing else but impressive in the field of learning in general, and PBL in particular.

Erik Bjurström, Vice Dean of research in Høgskolen i Hedmark, has been an encouraging "fan" during my last two years and helped me when my motivation was low and also been a good and knowledgeable friend that has never hesitated to take time to answer my questions on psychological and methodological aspects I did not understand.

So how was it possible to row this boat in to shore? Well if it was just for me the boat has sunk a long time ago. My tutors Erik de Graaff and Bettina Dahl Søndergaard have been just wonderful. I have never met a person like Erik who "knows it all". And I have really appreciated all your time explaining for me why what I have written is more or less rubbish. I am still ashamed of the first "study plan" I sent you. That must be a candidate to the worst garbage anyone ever presented as a draft for a study plan! But the message has slowly sunk in and I have learnt so much during this time I have had the privilege to get your advices and comments. My English still sucks, so taking that English class you suggested did not help that much. I am a poor language learner and will so remain. The last couple of months you and your wife have been on my mind each and every day. Bettina is nothing like Erik, besides an almost endless source of knowledge and encouragement. You have presented me with a never ending stream of literature suggestions and, quite frankly, a huge amount of papers and book suggestions, most of them of great interest. When you thought I should add

something to the methodology chapter on the objectivity of knowledge, I dropped like a stone in water drowning in a seemingly endless pond of books and papers, and this became the most difficult task so far. But after some tips from Erik Bjurström I could take a couple of deep breaths and dig myself in and learned some more. You are both a great inspiration and I am blessed to have met you two.

I have a terrific boss at Signals & systems and I am thankful for all the encouragement you, Anders Ahlen, have given me during my time at your department. Now it is your turn to "read the book"!

To Sofia, my precious daughter, I would like to say: Me becoming a doctor is perhaps no big deal, but it shows that anything is possible if you are motivated.

My late parents could not witness their son presenting his thesis, but for a farmer boy who completely overwhelmed his mother with questions of curiosity from every aspect, I am truly grateful for the encouragement the first couple of years and later pushing me into higher education, although the tradition in the family was close to nothing. I really had no clue what higher education meant and it was a lost 19 year old kid that got off the train in Uppsala the 10th of September in 1984.

Foreword

This thesis is a limited attempt to figure out if there is a way to perform better education on a large University traditionally all into research where education is something secondary, and a must for most of the seniors. The theory behind it is also limited from mainly three sources and developed from there: John Dewey pragmatic view on education as something that has to come from the pupils interest, David A. Kolb's work on Experiential learning theory (ELT) and his proposal for learning styles, and the lecture-less teaching of Problem-based learning in the Aalborg model. From these three influences the journey has traveled in all kinds of directions and the filtering part of what is relevant to the thesis has been the main part of the work since so much is written in social science and psychology about teaching and learning. This means that such big influences as Oxford and Cambridge (Oxbridge) tutorial method, psychologist Carl Rogers, pedagogue Lev Vygotsky, to mention a few, is not covered or taken into account more than unintentional or implicit. Just by studying Dewey you get enough information to write a thesis on his impact on the education system globally, and perhaps more surprisingly the lack of impact he apparently has. Dewey was born in an exciting time of development of social sciences because of the evolution theory presented by Darwin and the church's diminishing effect on the society as a whole. Suddenly, religion was questionable, and in many cases proven wrong on the most fundamental truths about earth and mankind. Therefore, it became legitimate to investigate and examine the mind of humans from a strict scientific point of view. Even this fact should be enough for filling at least a thesis on the development of human science and psychology and philosophy, with a direct effect on teaching and learning. The further the writing of the thesis progressed, the deeper the sea of educational science has become, not surprisingly, but also a clear view on how easy it is to point out a few key variables on what makes learning effective and nurturing for the student. It is the author's absolute conviction that, just as an example, learning has little to do with age: We learn our whole life and there are various approaches that suit different people in diverse situations, and age has not that much to do with it. In learning the premises are almost the same when- and wherever: You face a problem or a task. You use your knowledge, experience and curiosity to solve the problem or manage the task. The drive to succeed and the complexity of the actual situation determine IF you succeed, and HOW LONG it will take.

I am a lecturer in electronics and automatic control and 51 years old. I am a secondary school teacher in mathematics, physics and electronics and have also a master in pedagogical leadership. In the beginning of my working career, I was a professional golfer but teaching has been my main interest. I have taught both adolescents and adults during more than 25 years and in higher education since the end of 1999. I have also been the head of the Swedish Professional golfers association's (PGA) training for teaching professionals during 2002 and 2004. Throughout my service, I have always been fascinated by the connection between learning and teaching and why it is important to know the difference between them. By teaching golfers I early discovered that telling someone what to do seldom solve the issue, for some reason that is not understandable for most pupils. In golf, it became popular in the 90s to talk about VAK, Visual, audited and kinesthetic, learning: the golfers responded differently on these types of instruction. By my own practice, I soon discovered that the real problem was not so much what type of instruction you used, but how well you could understand what the pupil felt and thought about their game and swing. Therefore, many lessons in golf became more of a communication "battle" to figure out what went on in their mind. Of course, there is more to golf instruction than this, but this was something I could relate to in my practice in the classroom with my younger students, and later with the adults. When becoming a teacher in higher education I must confess I trusted, and enjoyed, the chalk and talk-lecturing as the solution for instruction, not need to get too involved with all the students. Still I worked with various active learning methodologies like Problem and project-based learning and tried different exams, mostly oral, but the foundation of my pedagogic was the lecture in front of the blackboard. In 2008, I discovered that my efforts were not good enough so that something had to be changed and done to be a better teacher. Since I was familiar with the different learning styles from Kolb (1984) and my experiences from the golf lessons, I soon became aware that there was so much more to higher education than a deductive approach towards more or less passive students. Therefore, I decided to become a really good teacher and instructor and search for the perfect teaching model. After getting some founding from the faculty to develop my skills and knowledge the ball was set rolling. This thesis tells the story of my journey.

Everything is relative – even knowledge. This means that knowledge is more or less complex depending on the learner and his surroundings. Therefore, what seems impossible for one

person is completely obvious for another and everything in between. Knowledge cannot be categorized as in the taxonomy by Andersen, Krathwohl and Bloom (2001) without pointing out an individual and in what context the problem occurs. That is part of the findings from my experience and study of the humans learning in an environment shaped by academics to create producing engineers. In teaching you almost to never have the opportunity to have one student at the time, so the content has to be organized in a context presuming some knowledge and with defined outcomes of the studying. Thus to improve as a teacher or instructor you need to learn as much of the threshold your students' experiences as possible, and invite all of them to discussions to understand their prior knowledge and motivation to learn. Since remembering is closely related to merely procedural knowledge based on algorithms, "chalk and talk"-lecturing is simply a grey mess based on your assumptions of people you never met and does not know. The self-regulated students do not mind (but can find it boring and uninspiring) this vague form of learning, but the majority of your audience will struggle for both in understanding as well as engagement of what you "rabble" about.

I am a teacher in electronics at Uppsala University and have experience from teaching on all stages from intermediate level to adult education. I have a master in education (special teacher) and another in pedagogical leadership. Besides a career in golf as both player and instructor, most of my work has involved teaching. Throughout my career, I have always been fascinated of what (does not) trigger your curiosity. The last couple of years I have been mentoring inexperienced teachers, yet another way to develop as an instructor. The curiosity for teaching and learning and the (in-)ability and (lack of) motivation of my students made me investigate if there are an optimal model and/or environment for learning. It can sound somewhat naive, but it was important to start with a vision, although I understood that no such solution is available; hence the relative statement above.

It is not easy to give advice on how to teach in general terms. However, there are lots of well-written books and articles on higher education and its practice. Some of them are listed in appendix 7. What can be learned from this thesis is to sort out the content as facts, concepts and procedures that will form other facts and procedures in the same way. In tune with being interested in their learning, very well structured, presenting problems that make sense, and creating the best learning facilities you know, there is nothing more you can do.

Thereafter, it is all up to the student to interact with you and the course content. Speaking of advice: It is highly appreciated by the students if you know them by name. That simplifies the communication wherever you meet; the lecture hall, the laboratory, in the corridor or by the coffee machine. It is worth so much in breaking the walls around you as a professor if you can address your students by name (and a smile)!

It is easy to make a course that suits today students' well. If you follow the protocol of presenting the course objectives and how the teaching will be performed on the first occasion, you then "only" have to give them weekly mandatory assignments to hand in practicing problems closely connected to the course objectives, and then give them a written exam based on the assignments. Lots of students will then pass your course, and you will probably earn good evaluation grading from the students. There will be notes in the evaluation form about how much work they put in and probably also that the other courses parallel had suffered because the mandatory assignments took (too) much time. But what happens if all three (or two) courses have the same planning? Will the students still work so hard that they hand in the necessary assignments each week? What happens if a large group of students fail to hand in the assignments right from the start? It is quite possible that one week becomes too hard for the students because of circumstances other than pure motivation or hours spent studying. There is an obvious risk that several students are left behind right from the start, and the ambitious plan for the students fails miserably. Higher education benefits from a voluntary decision from the students to study a program or a set of courses. If you are the teacher of one of the parallel courses to one presented as above you will most certainly experience that lots of students will put a lot more effort in the course with mandatory weekly assignments. It becomes like a competition between teachers from which course gets the most attention right from the start; someone will most likely suffer from the other course strategy. Therefore, it seems desirable to search for other answers, i.e. help the students in the process of becoming self-regulated learners and find their own motivation to study hard enough.

Consider Kolb's ELT and the legacy of Dewey, Lewin and Piaget "as the foremost intellectual ancestors of experiential learning theory" (p 15 Kolb 2014) and apply that on modern higher education. More and more students struggle to pass courses, mainly due to the inability to focus and work hard on things that involve learning new facts based on concepts and

procedures. The following model is easy to use and, what really stands out, is understandable for almost all students who pay some attention: After presenting the course and its objectives you shall divide the content into modules, which has a clear base of facts that will be used in a context, mostly (all!) conceptual. Present the facts and the context in which they will be used. Use the proper context to present the concepts to learn. State the new facts that come out of the concepts based on already known facts. If the material is possible to realize in practice, do that, and the most important part of it all: Let the students hand in their own experienced facts to be used at exam. This is a practical approach that considers all aspects of teaching: Clarity, structure, ELT, whatever used active learning theory, 100% responsibility for the student, and a possibility to try out the theory in practice AND formulate the new knowledge hereafter known as facts, without a whip. After module, you just formulate the next in the same way. The whole course (a semester, set of courses, even a whole program) is now a 100 % transparent chain of facts to use and learn in active learning, whether you are a procedural or conceptual learner.

This becomes even more important if you trust that conceptual thinking is independent of an individual´s ability to use procedural knowledge (Baker & Czarnocha 2002). Since the students become aware of what procedural knowledge to gain they must make sure they reach it, no matter what it takes. This makes teaching and learning more interesting and just knowing that should increase motivation, or at least make them more aware of their own responsibility. If they do not reach the next level of facts it becomes hard to hand in notes for the exam since they have not reached the level of understanding conceptually.

This is my story (read narrative) based on my experiences from a life of curiosity, twenty-five+ years of teaching and a couple of years of inquiries.

What is experiential learning and a narrative study? I can say that it's a fact that when two people not knowing each other says hello to each other; it can be on your workplace when you meet a cleaner in the corridor or when you meet a stranger in the stairwell where you live, the person you meet will most likely say "Hej hej" or "Hallå hallå" if you are in Sweden. If you know the person well you will never repeat the greeting; you will both use one word or phrase. To establish the convention in research you need to make a survey that backs you up. The generalization is hard to get because there isn't a number high enough to verify your

statement completely. So when doing research on humans the generalizations must stand aside. To what use are they then? The world, as the human, is in an endless evolution because of natural selection and the strongest survive. Humans develop because of evolution and natural selection, but also from our ability to build knowledge of experience. So the complete meaningless result of my inquiry on how to say hello in Sweden still contributes to the learning and understanding of us and can both be used for new knowledge or simply just ideas based on my observation. Furthermore, by telling stories about our experiences we can educate and inspire other humans to investigate and learn from experience and listen to their stories.

This thesis tells my story of my experiences on teaching in higher education at a University solidly framed in a deductive teaching environment dominated by "chalk and talk"-professors. The study is actually a good example on how Problem-based learning (PBL) and experiential learning are used in higher education: Each study has a general problem to be solved and the next study uses the results from the previous to reach a goal; namely this book.

If we accept the content which shall be learned as a starting point, basis, for research within pedagogical psychology. This will lead to that you don't so much study the learning process as such, but rather focus on the learning process, understanding and problem solving in relation to different concepts, principals or phenomena.

Besides a general guidance for studying (Go for understanding, holistic approach and education based on the students own experiences) research can only provide the teacher with instruments for the analysis. It can describe possible effects and necessary conditions (qualifications) (Marton/Säljö 1977, p. 164)

Chapter 1 - Introduction

Background

The story begins at a research-intensive University in 2010 at the department for engineering. The teacher is frustrated because so many of his students fail the exams despite the fact that the content is well prepared and presented. The year before has brought his first bad course evaluation so his courses seem dull and not very inspiring. The reason for his switch to become a University lecturer was mainly because the content would be the main ingredient in the smorgasbord offered to the students, not depending on making it fun, taking care of discipline and sit in endless meetings discussing different approaches to make the students work better and more efficient. But time has caught up with our lecturer: The students are not satisfied with just lectures and lessons, complemented with laboratory work and study visits, presenting the content anymore. It would have been easy just to sit down and complain about the students getting worse and to blame it on their prior knowledge not received in their earlier stages of the education system, but he decides to make a change and see what he can do to: 1. Give better learning opportunities, and 2. Make the students happier with the teaching. A key problem is the fact that the students seem not motivated enough to read the textbooks: How come? Why do they depend on lecture notes and lessons given by the teacher? The teacher is well educated (master in science education and pedagogic leadership) and has been studying group learning, Kolbs learning styles, and his experiential learning theory (ELT) (Kolb 1984). As a curious person in general and an urge for development he signs up for a course in assessment of pedagogic skills and another in mentorship for new teachers. Both courses are rewarding and he gets commissions both inside his University as well as from other seats of learning in higher education. Mentoring and assessing other fellows helps structuring his inner thoughts of what really matters in teaching and he becomes more and more convinced that his concern to be a better teacher is mainly due to the engagement from the recipient. So his first attempt is to make the meetings with the students more engaging. Earlier he has tested lots of different learning environments such as project courses, continuing examination, problem-oriented courses where the course aims have been presented at the beginning of the course as problems that shall be solved and examined during the course, some of the attempts with really good results, other not that different from the standard course he is

used to. From the director of studies he is ordered to plan an introductory course for electronic engineering students only using the knowledge they already have. The main reason for this is to give the students a start where the engineering perspective is in focus, and not so much new academic knowledge to confuse and complicate for the students. The course becomes 100 % practical and consists of a project where they use readymade parts for flying a radio controlled airplane to be built. Despite being a nice way of spending time with students and lots of laughs and some creativity building the aircrafts, the drive for mastering the assignment is not quite there. This puzzles him and leads him towards Problem Based Learning (PBL), and the Aalborg model in a book written by Kolmos, Krogh and Fink (2004). After reading the book and implementing some of the ideas he gets the opportunity to advance in the field of education in engineering sciences and starts a journey towards better understanding of the teaching and learning process. To make the students more active and participate in the lectures he discovers micro teaching and active learning in the classroom

Micro teaching

The idea was to prepare for a better communication in the classroom. It would be so much better if the students came prepared. Previous attempts were limited to instructions on what to read or calculate until next sessions and this was almost always ignored. So he needed to discover a way to "fool" the students to prepare without taking too much time or effort spent. He have heard somewhere that you can only stay focused 10-15 minutes at the time listening so the idea of creating short lectures recorded handed out before the lecture became the first approach towards better communication in the classroom. When studying different aspects of micro teaching he noticed that not only can you prepare the students for the class, you can also focus on more problem-oriented questions and tasks. This was from the PBL format (ibid) where the students were exposed for real life problems. So the first attempt would include short online lectures on the theory basics; the boring necessary new content (later known as facts and concepts) to understand new processes with new components (in an electronics course). Much of the initial planning retained learner-centered teaching because of the influences from Kolb's ELT and the Aalborg model of PBL. Still the content was to 100% determined by him as a teacher, following the curricula. The pre-lectures had two primary goals: Increase the communication in the classroom during

lecture, and promoting more real life problem solving during classes, not spending valuable time with the students covering the basics of the new content. To be better prepared for more communication he learned all the students' names right from the start of the course. Despite not knowing it, he took a huge leap into the learner-centered model of teaching.

Micro teaching techniques have been used from the 1960's in a whole range of functions to improve teacher's behaviors in learning environments (Brown 1975). As an example it was used in teacher training to teach a small portion of a lesson to a small group of other teachers under strict supervision evaluating the performance to prepare for the lesson for real students (Higgins & Nicholl 2003). Kilic (2010) explains that teachers are viewed as facilitators creating a learning conducive environment in the process of learning instead of being knowledge transmitters and skills models, as seen before. According to Kilic curricula's that support development of team work, interactional skills, new market demands, and learner-centered teaching and learning approaches have been adopted in several countries (Nielsen 2004). Teachers shall therefore make knowledge more practical giving learners' responsibilities and lead them to construct knowledge in their mind (Beydoğan 2002). Further from Kilic developing good communication with learners can help to create a successful learning environment and perform effective teaching (Celep 2001). Learning their names helped to promote this process and he set up the goal to get to know all the students individually. Not putting learners in the center of education means viewing knowledge and learners as immutable entities (Kilic 2010); both learners and knowledge are changeable. Knowledge and skills based on (learner-centered) experiential learning can be understood more extensively and permanently (Lont 1999).

Active learning

Kolb (1984) makes the distinction between just thinking and argues for that active learning develops from thinking about the details of the thoughts, experiences, perceptions, and emotions that occurs from experiences. So active learning involves four stages of concrete experience, observation and reflection on experience, forming abstract concepts leading to new experiences. Active learning takes place when these four stages are materialized and followed in its logical order. An action research cycle was defined by Kurt Lewin and others (see below) starting with

1. *Finding a focus,*
2. *Clarifying the focus,*
3. *Implementation,*
4. *Evaluation and dissemination, and*
5. *Beginning of another cycle? (2-5 repeated).*

The cycle was proposed as a rigorous approach to improve our practice (Mills & Butroyd 2014). Kolbs experiential learning theory (ELT) is connected and developed from the work of the 20th century developers of theories of human learning and development: Lewin, Dewey, Piaget, James, Jung, Freire and Rogers to mention the most influential (Kolb & Kolb 2012)

The following definitions of concepts are used:

Action research cycle - the four phase cycle (2-5) presented above; an iterative and progressive approach adapted from Kurt Lewin.

Action researcher – can also be called practice researcher. The researcher (as the teacher and instructor) interacts with the students to improve the practice (Elliot 1991).

Mixed-methods research – The outcome of the study is normally based on qualitative research but quantitative measurement can be applied if appropriate (Mills & Bytroyd 2014).

Kemmis (2010) argues for three kind of understanding as the goal for science, research, or action research:

1. *The external truth that may accumulate in scientific theories,*
2. *Interpretive or hermeneutical understanding that might origin from education, interpretation of art, or learning from history, and*
3. *The wisdom and self-knowledge from experiences and/or reflection on experiences.*

He argues further that action research not only contributes to theory but also to history, i.e. the development of "the whole" as the evaluation theory. Sustainability is dependent on the development of action research.

At this stage the process of experiences of learning theories had lead him into understanding the concept of active learning suggested by Kolb. So how can he then promote and create the active learning for the students? Despite the appreciated pre-lectures and more

interaction during class, the results showed no significant improvement. What came as a surprise was that many of the students used the online lectures as repetition towards exam. All of the lectures included basic examples on how to use the new knowledge, which is probably why they returned to them. At the same time a colleague had developed an online tool for flipped classroom[1], posting pre-lectures with quizzes compulsory for the students. Since it is my firm conviction that most, if not all, learning environments at the University shall be voluntary, I used the online tool but without making it mandatory. Another component added to the teaching was lessons where they were encouraged to work in groups of six to eight, facilitated by him. So, his students were happier with the teaching but still the same old disappointing results in terms of passing. What stood out from the exams was that the students that passed got better grades than before. A thorough review of books on active learning and PBL started, and a large number of published papers on research in higher education helped him to state the following research plan:

Problem definition

A major problem in engineering education these past years is the fact that students show great difficulty in completing courses. Partly this comes from the fact that the number of students for politic reasons increased dramatically. Courses that require abstract thinking seem to be the most vulnerable. The passing rate on my own courses (as a teacher in Electronics) has been lower than 50 % a year. I've been searching some time for key elements which could help students get a better conceptual understanding in analogue electronics, and I've developed study material which focuses on getting the students to start discussing the topics during class in the course. However, there seems to be more to it than just getting the communication going in the lecture room. That has caught my attention and now I aim to investigate what factors make today students seem to miss out when courses requires a higher level of abstract thinking.

The demand for deep learning ability should increase when you start studying at the university. The concept of deep learning and conceptual understanding is treated and defined in Marton/Säljö (1976a and b, see Greasley Ashworth 2007). This means higher demands on the students considering capacity and motivation. Capacity can be measured in "ability" and "time". Success in studying requires therefor three variables, namely ability,

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[1] Scalable learning, see https://www.scalable-learning.com/#/home

time and motivation (Another expression would be effort). Ability is partly congenital, and partly a result from previous learning, at a certain time it´s nothing you can change: your ability is what it is. The amount of time someone is prepared to put in is an indicator of the motivation of the person. How much time you're willing to invest reflects the experienced course importance in its context, often as a part of a program. If the course is compulsory, that itself is a motivation factor. Once you decide to participate in a course there are several more influencing factors: The course presentation and introduction, the curricula, the teacher's engagement to mention the most obvious. My work aims to measure the students' incoming ability; decide the students' motivation taking the course, and the development of these abilities in different phases of the course.

The provisional name for the study is Students' (in-) ability to deep learning and conceptual understanding. The study will apply mixed methods with a clear social constructive theoretical background (Creswell 2009). The teacher and the students shall on the basis of a new strategy reflect from their own experiences, apart from the measurements of the students' conceptual knowledge level.

The planning is firmly based on student activity methods and there are larger problems/tasks that the students are supposed to solve almost unaided. There will be micro teaching, discussion forums and support from facilitators. The ideas from PBL, problem based learning, are used for example at engineering education in Linköping, Maastricht, Aalborg, Roskilde, Ontario and Newcastle in Australia.

PBL is based on pedagogically experience of learning by doing, and the first theoretical foundation for it was written down by John Dewey as early as 1910 as a method to solve ordinary problems and scientific processes. He summarized the principals of this problem solving method with the expression Learning by doing. Project work and PBL is based on the same learning principles and is similar in many ways, even if they as teaching models differs some. In brevity you can say that the methodology within the project work is developed in Denmark at Roskilde and Aalborg University, whereas PBL is the name of similar teaching models around the world, in Sweden as well among others. Personally I found little or none reason to separate the models then they have the same origin and the same learning goals and outcome. Theories around this can be found amongst Negt/Kluge, Illeris, Holten-

Andersen on the Danish side, and Kolb, Schön, Lave, Vygotsky, Luhmann and Wenger at the rest of the world. For a more detailed analysis of the various project-organized learning appliances, and in comparison to traditional engineering curricula, see deGraaff and Kolmos (2003).

The idea to make the teaching more as forums for discussions is another step taken from deductive method to more inductive.

Objectives and research questions

My study aims to compare the students' conceptual ability and motivation to take on the course, with the outcome of the course, conceptually as well as through completed course. Conclusions can be made whether there is motivation or pure class, or a combination of them, which is decisive to pass a course considered quite difficult. The study shall also highlight the students own experiences of a study strategy which is the basis of their conceptual development of understanding. There shall also be a part where the students experiences of a more student active methodology is compared to the more deductive teaching they're used to.

The objective is to gain understanding of the factors that influence students' mastery of abstract thinking. In order to achieve that goal first the students' conceptual understanding from previous courses will have to be determined. (*Quantitative Q*) The following research questions can be specified:

Research Question (RQ): How does the composition of working groups affect the way of working and the result for the group as a unit, and of the individual student (This Q is both *qualitative*, their own opinion, as well as *quantitative*, the actual outcome of the exam). RQ2: What is the conceptual level compared to pure knowledge of hard facts in the previous courses? (*Quantitative*). Is there a connection between the result of the exam and the conceptual level of understanding they started the course with? (*Quantitative*). Sub Question 2.1: Does the grouping play a measurable part for the outcome of the exam? (*Quantitative*). How do the student experience the more student active way of method compared to a more traditional one? (*Qualitative*). How has their conceptual understanding developed during the course? (*Quantitative*). SQ 2.2: Is it better, worse or not changed? Who are the most important motives for the students to participate in the course?

(*Qualitative*). SQ 2.3: Do the students experience that their self-efficacy increases during the course? Regardless the answers: Why is that? (*Qualitative*).

For evaluation and data collection questionaries' and interviews were applied for the students.

Chapter 2 - Theoretical background and research considerations

Introduction

There should be little doubt that teachers in higher education strive for students to comprehend and dig into the course content and show good understanding of the course aims on the exam. Unfortunately, that is seldom the case and sometimes the course ending up in disappointment over the course complaining it was too hard, the exam was not in proportion to the planning, etc. It is then easy to complain on the students' lack of necessary prior knowledge, lack of enthusiasm, no communication during classes and low presence on the lectures and so on. The times have changed and there is a significantly larger number of students in higher education. The Internet has revolutionized the social life as well as the information exchange and availability. Modern welfare in the west has created a phenomenon of spoiled children where the parents sweep the ice in front of the cruising children to make life as easy and comfortable as possible. You do not have to go out any longer to meet your friends. Most social life is available online so you do not need to activate yourself to spend time with your friends anymore. You can learn languages by using smartphone just to give an example on how the instruction and learning has changed dramatically the last decades. Therefore it comes to no surprise, although that we are getting smarter and have more information at hand, the old learning institutions must adapt to these new conditions in for example higher education. So what shall we do with these "spoiled brat's" that preferably would like to stay home in front of the computer instead of attending endless uninspiring talks of physics, math and history, presented in a format that has existed for more than 500 years? This thesis wants to put forward the argument that if you are familiar with renowned pedagocic researchers of the late 19th century to the middle of the 20th: They knew what were wrong, and presented ideas on how to make the school system an inspiring and effective practice of learning. Unfortunately, and indeed surprisingly, not much has happened. The one school system is still the dominant mandatory education system around the globe. "Chalk and talk"- or powerpoint-lectures still dominates in higher education, although we are well aware of its ineffectiveness. Confucius words echoes still in a rather empty hall of practitioners. There are as mentioned lots of studies and theories on the learning process, and of course a large number of good examples from teachers as well as learning environments such as Universities.

Key concepts

Research on efficient teaching and learning reveals some key concepts: Deep and surface learning, inductive and deductive teaching, conceptual and procedural understanding and knowledge, intrinsic and extrinsic motivation, group learning, self-efficacy, to mention some of the most frequent. There are certainly more concepts that could be considered, but the theme of the thesis is based on a frustration from a long experience in teaching, and the trust in studying lecture notes and previous exams to pass the course, and the earned knowledge is forgotten in a hurry. In this chapter the key concepts will be reviewed from research and interpreted to a proper context.

Research design

The development of research in social and psychological studies has accepted the qualitative analysis of data since studying the human and their interactions with other humans and in different groupings is situational of the participants, purpose of interaction and so on. Studying teaching and learning will thus produce data considered as qualitative. There are many interpretation models to be used when analyzing qualitative data. A mixed method's research incorporates both qualitative and quantitative approaches. What is best at different occasions must be decided during time and can change: Is the exam result useful data or is the students' opinion on what have been learned more valuable? Shall we use both sources of information? What is worth more or less? The analysis from the upcoming situation and outcome of the surveys will decide the next step of the process, although there is a "master plan" decided to begin with. It has to be some flexibility built into the chosen research model: Since the interest in qualitative research has increased during the latter 20th century there has been a development in mixed method's research (Creswell 2009). From Creswell (2009 p. 4):

- *Qualitative research is a means for exploring and understanding the meaning of individuals or groups ascribe to a social or human problem. The process of research involver emerging questions and procedures, data typically collected in the participant's setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data, The final report written has a flexible structure. Those who engage in this form of inquiry*

support a way of looking at research that honors an inductive style, a focus on individual meaning, and the importance of rendering the complexity of a situation.

- *Quantitative research is a means for testing objective theories by examining the relationship among variables. These variables, in turn, can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedures. The final written report has a set structure consisting of introduction, literature and theory, methods, results, and discussion. Like qualitative researchers, those who engage in this form of inquiry have assumptions about testing theories deductively, building in protections against bias, controlling for alternative explanations, and being able to generalize and replicate the findings.*

- *Mixed methods research is an approach to inquiry that combines or associates qualitative and quantitative forms. It involves philosophical assumptions, the use of qualitative and quantitative approaches, and the mixing of both approaches in a study. Thus, it is more than simply collecting and analyzing both kinds of data; it also involves the use of both approaches in tandem so that the overall strength of a study is greater than either qualitative or quantitative research.*

As a researcher it is of great importance to think through the philosophical assumptions from your perspective and what it brings to the study. From there, specific methods of research help you formulate your approach into practice (ibid). So the mixed methods approach forms a sequence of inquiries adapted to the upcoming situation. It is grounded in your philosophical assumptions and controls the further steps of your data collection. Although research is done to better understand the world and, in this case, the human mind and intellect, the absolute truth cannot be the goal: All evidence is always imperfect (Phillips & Burbules 2000). All proved data and true statements are situational and hopefully valid, in some sense, of the surroundings. Because all data collected is done by humans, there is no such thing as objectivity. "Objectivity" can be obtained between persons and/or groups of persons (conscious minds), i.e. conclusions and theories can be considered inter-subjective. Methods and conclusions are always affected by some bias. The researcher has to be very careful in deciding what causes and disturbs the data. So for example the laws of physics are merely a picture on what we know right now about the earth and space, but it is proven with the knowledge and research environment we can provide for now. Studying behavior on humans can thus be interpreted for that human in that situation. Generalizations become

hard to motivate because no human is alike, and every social environment differs from one another. The post positivist view represents the traditional form of research. To seek for understanding of humans and how they function in the world all research and inquiries become subjective and relative to an environment impossible to recreate. Therefore, the research becomes interpretive from many views; it is all about describing the framework of your study and what conclusions you draw from your collected data. This social constructive view is the foundation in qualitative research. So a social constructive study focuses on the context in where it is performed, and the processes of interaction between individuals who occur. The questioning tends to be more open-ended to understand better the objects history and experience. All individuals (re-)act from the culture, history and knowledge he or she has experienced. There is perhaps a drive for researchers to strive for generalization of a theory, but in order to create good or excellent research the social perspective prohibits the results from being general. So the purpose must be too as clear as possible describe the environment and circumstances for your study, and make conclusions from lucid research questions and what variables accounted for. There are many times a political agenda for social constructive research in learning and teaching since schools and institutions for learning are often governed by the authorities: The research is conducted to reform or change something for the participants and/or the institution. Therefor the research often includes the researchers as well. More about the research design will follow in the Methodology chapter (5).

Kurt Lewin and Ralph Tyler

Participatory research is called action research, and Kurt Lewin is often mentioned as the creator of the concept. Lewin performed lots of studies of organizational behavior and the social interaction between individuals. Two of Lewin's former students, Dorwin Cartwright and Alvin Zander, summarized Lewin's view on how democratic participation gained better productivity than autocratic coercion. "Action research was the means of systematic inquiry for all participants in the quest for greater effectiveness of democratic participation" (Adelman 1993 p. 7). The political agenda for Lewin was in particular to raise the self-esteem of minority groups to gain independence, belonging and equality through action research (Lewin 1946). As a side story, to even more cement the political agenda for Lewin, comes the fact that he was raised in Germany and fled in 1933 and his practice was influenced from the

exploitation of the colonization of the world in the late 19th and early 20th century leading to a strong autocratic leadership with a large group of citizens suffer from oppression, not to mention the horror from the 1st world war. His work as a consultant on the Harwood factory in Virginia investigating how participation on how to educate employees to increase the morale and productivity compared to workers that remained in an autocratic leadership with not much to say or influence, is a milestone in the discipline of action research. At the same time Ralph Tyler (1949) wrote an important book on how to formulate and address curriculum and instruction in education. This was one of the first approaches where the learner stood in the center of the process of creating meaningful learning environments. He understood that education was a process of changing behavior of the students. He emphasized the importance to consider the conditions and opportunities of their contemporary life in creating learning objectives. Instead of determine what students need to learn in the beginning courses of the subjects in secondary schools to master the content later in life, the curriculum should answer the question on what are the contribution of the subject to learn for students not going to be specialists in the field. Tyler also makes the connection between science and the cult word of the 21st century in engineering education, sustainability. By connecting science to common concerns of the public like health, conservation of natural resources and provide for a satisfying world-picture, he suggests that these concerns can infer to many good important learning objectives in the science field; promoting objectives related to knowledge, attitudes, problem solving abilities, interests and alike. The connection between science and major areas of human relationships is mentioned as an "excellent illustration" of subject specialists' contribution to the development of the curriculum in science classes.

John Dewey

The step from Tyler and Lewin to John Dewey is not far. The chronological order is reversed some, but the journey towards a practice colored by learner-centered teaching and learning passes Dewey, one way or another. Dewey was born in 1859 and experienced the aftermath from the Civil war (1861-1865) during the 1880s where the political agenda through the President James Garfield supported a civil-service reform. The political system in Washington was weak and full of corruption so the impact of their decisions was far from being accepted and accomplished in the whole of USA. Garfield was murdered, and Chester Arthur took over

and became reform friendly and signed a civil-service reform bill. The reform did not reach much legitimacy in the country so the growing poverty together with the rapidly expanding industry ended up in the great depression in 1893. This was the culmination of the establishment for the union and cut in wages, miserable working conditions and an increasing unemployment resulted in numerous strikes where the blood literally flowed. This was an important input of motivation for Dewey as well as many other things such as his six children's experience from school. Since Dewey from his own years as an adolescent was disillusioned with conventional educational practice, and the whole continent was changing rapidly because of the political climate described above, but also from the revolution in science where Darwin's evolution theory had put all knowledge gained from religion on its toes. The church was for the first time questioned by other authorities, and begun to be over proofed by knowledge from science.

He mastered in philosophy and started his graduate schooling at Johns Hopkins University in Baltimore. It was established in 1876 and became the first University with a clear focus on research. He studied for Professor George Sylvester Morris, Charles Sanders Peirce and G. Stanley Hall and joined Hall's research group despite that he liked Morris' ideas (from Hegel) better. Hall's interest in fusing philosophy with psychology and psychology with education became decisive. Morris was more for the whole picture of philosophy rather than Hall's experimental approach to science. The influence of logic as a mathematical contribution to philosophy, which was the agenda for Pierce, was nothing for Dewey. According to Martin (2003) Dewey wrote in a paper that modern philosophy "abandon all legal fiction of logical and mathematical analogies and rules; and is willing to throw itself upon experience" This ignorance of Pierce was later revised, and he finally understood the importance of Pierce's work.

His teaching career started at the University of Chicago in 1894, and he immediately began his practical work in pedagogy (Westbrook 1993). From How we think (1933, revised ed.) through Democracy of education (1998) to Experience and education (1938) he shared his legacy to educators on the "necessity of testing thought by action if thought was to pass over into knowledge" (Mayhew & Edwards 1966 p.464). The production includes so much more, and most of it is available online. In Experience and education, he compares traditional and progressive education, and states that in traditional education the

fundaments are limited to what is already known, and the experience of the learners is not taken into account. So traditional education even prohibits new learning. By adding experience and ability from the learners he argues:

> *If one attempts to formulate the philosophy of education implicit in the practices of the new education, we may, I think, discover certain common principles amid the variety of progressive schools now existing. To imposition to above [traditional education] is opposed expression and cultivation of individuality; to external discipline is opposed free activity; to learning from texts and teachers, learning from experience; to acquisition of isolated skills and techniques by drills, is opposed acquisition of them as means of attaining ends which make direct vital appeal; to preparation of a more and less remote future is opposed making the most of the opportunities of present life; to static aims and materials is opposed acquaintance with a changing world. (Dewey 1938, p. 19)*

Further he points out the risk in deprecate the old and embracing the new is not solely a step towards positive and constructive learning: The focus is on rejecting the ancient instead of developing fresh thinking for knowledge. The need for experience in learning new knowledge is not something that comes automatically. Experience has to be educative. Experiences may be disconnected to each other creating confusion and a scattered mind for the learner. Traditional schools are not free from experiences, but they are defective and of wrong character. "The quality of the experience has two aspects: There is an immediate aspect of agreeableness or disagreeableness, and there is its influence on later experiences" (Dewey 1998, p. 27). The educator has to arrange the kinds of experiences so it does not repel the students. "Hence the central problem of an education based upon experience is to select the present experiences that live fruitfully and creatively in subsequent experiences" (ibid p. 27f). Dewey calls it the experiential continuum. "The more definitely and sincerely it is held that education is a development within, by, and for experience, the more important it is that there shall be clear conceptions of what experience is, Unless experience is so conceived that the result is a plan for deciding upon subject-matter, upon methods of instruction and discipline, and upon material equipment and social organization of the school, it is wholly in the air" (ibid p. 28). For progressive education, the philosophy in

question is (paraphrasing Abraham Lincoln on democracy) education of, by, and for experience. The change from traditional education becomes far from easy because of the challenge of discovering principles on order and organization from understanding the signification of educative experiences (ibid p. 29). During Dewey's life the world changed from the colonization period, world war I, voting rights for women, the great depression, democracy and all people are equal; quite a revolution for the mankind. The democracy was now considered the best of all social situations (ibid p.34). The evolution theory by Charles Darwin confronted the church and ended the religion's unique position of being the answer for life and its meaning. The education system was built up and the demand for progressive schools soon challenged the traditional system where all knowledge was fixed and the teaching was bound to bring about what to learn and how. It was simply no Either – Or task; All what was required was not to do what is done in traditional schools (ibid p. 30). After motivating the need for a theory of experience the following criterion of experience was the result of a philosophical analyzes (often with a humane and democratic ideal as a foundation for reasoning): The value of interaction and continuity in the process of education as growth. The educator must have the ability to judge what attitudes are conducive to continued growth and what are detrimental, and the same goes for the responsible of the programs.

Dewey's idea of a progressive school that provides conditions for good learning works well as a theoretic fundament for today's higher education: What is there to argue about creating continuity and interaction in the classroom when the goals for the programs are quite clear? In a Dewey way, it is therefore, also about creating the proper curriculum to support the growth of the students to become keen professionals. Dewey refers to "traditional schools" and since it still exists, tradition is a strong factor in higher education. One probable cause is the fact that professors rarely are educated in psychology and learning, making it natural to refer to past experiences from their own education. The legacy of learning becomes institutional. From Dewey, you can draw the conclusion that there is more than just teaching and learning: the whole system "school" must be considered in the view of experience providing growth through continuity and interaction starting with a clear path where "Every experience is a moving force " (ibid p. 38)... In practice, a program in higher education must be the result from a process which includes knowledge (through experience) from the market, political decisions (for example, example winding up the nuclear power and that

focus shall be on finding alternative sustainable and renewable energy), local enterprise as well as national and global, expertise of the community where the education is being held, and still not prohibit students from becoming independent entrepreneurs in a field of practice. It is though far from easy to skip the traditional way of setting up programs and courses since the experience plays a role in all the planning and execution of the learning community. And still nothing is mentioned regarding the students and what experience they bring, and the differences among them from their background. In summary, of the criteria for experience the present affects the future: Those who have knowledge about the connection between them have the responsibility to institute the conditions for the proper experience that has a positive effect upon the future (ibid p.50). Further Dewey highlights the importance of Social control and the environments that prohibit or nurture the growth in learning (the broad picture: not necessarily bound to the classroom or campus). From communication, a social protocol is created, and you act accordingly. Therefore, communication between students and students and authorities like instructors is necessary to create the proper environment needed to build a creative and developed community for learning. Using the monolog in your practice as a teacher cannot be good practice; you have to start up the process of interaction. This way, the students become contributors instead of passive consumers on an endless flow of talk from the educators. Is there though not courses that benefit from a rigid inflexible structure because this is something you all have to learn? A course in linear algebra perhaps? Experiences show that students in higher education fancy a transparent and rigid structure where there is little or no doubt from what to be learned and tested for. This becomes the same as completing a jigsaw puzzle: The task is clear and after it is done nothing more than putting the pieces together is accomplished. There is although a satisfaction in completing the task: You have completed something. However, there is a reason for learning linear algebra, and the tool's learnt shall (or at least can) be used to solve problems, for example, in calculating differential equations. Therefore, the content of concepts and procedures for the isolated specific problems has a purpose not to be ignored and forgotten. There is so much more in learning linear algebra than just putting the pieces together and show that you did. I would call this the difference between one-dimensional knowledge and multidimensional learning: The context of knowledge is as important, or, perhaps, even more important than the puzzling itself.

From the work of Dewey in general, and for Experience and education in particular, there is a tone that does not speak for a model (or "-ism") that is superior or even better than another, apart from the criticism for "traditional education." The development of education is a very complex matter, and you cannot just simply collect the best from two or more successful systems. Details that are working better at one place is not for certain the solution on another. The practice must constantly evolve from your own experiences, although good practices can of course become an inspiration or guideline for the future work. All change is harder to accept than following the normal path, so reactions will occur against all kinds of other influences. Thus the solution can never be a theory of education that works for all schools; it is far too complex and socially dependent to be written down as a recipe for how it is done. Education is about human relations, and as long as there are more than two people interacting. The social protocol will change depending on the subject at hand and the grouping. The thought of billions of learners every single day around the globe, makes you realize that Dewey's description of the importance of experience and the criteria's continuity and interaction are the basis on which the education shall progress. His contribution is therefore, for the writer of this thesis, the most important work in learning, and forms the framework for many other researchers and philosophers in education. The work of Dewey and Lewin structured the fundamentals of action research and experiential learning theory and how the sociocultural environments are related to the individuals.

William H. Kilpatrick

Dewey's pupil and colleague William H. Kilpatrick was, as Dewey, attracted to the project method of teaching that had its origin in the academics of architecture and later found its place also in the engineering education in the 19th century (Knoll 1997). In his book (1918) he argues for the purpose of The project method as a pedagogical tool for the progressive education to learn for life in a democratic and life-affirming way:

> *As the purposeful act is thus the typical unit of the worthy life in a democratic society, so also should it be made the typical unit of school procedure. We of America have for years increasingly desired that education be considered as life itself and not as a mere preparation for later living. The conception before us promises a definite step toward the attainment of this end. If the purposeful acts is exactly to identify the process of education with worthy living itself. The*

two then become the same. All the arguments for placing education on a life basis seem, to me at any rate, to concur in support of this thesis. On this basis education has become life. And if the purposeful act thus makes of education life itself, could we reasoning in advance expect to find a better preparation for later life than practice in living now? … In a whole sense the whole remaining discussion is but to support the contention here argued in advance that education based on the purposeful act prepares best for life while at the same time it constitutes the present worthy life itself. (ibid p. 6f)

This is argued from acceptance of the laws of learning from Edward Lee Thorndike's *Educational psychology*, Volume II, which was a result from studies of animals and observations of young children[2]. Kilpatrick concludes: "The purposeful act does utilize the laws of learning." (ibid p. 9). Much of his arguing is based on the conflict between forcing children to do tasks free from child's interests, creating impossible conditions for inspired and meaningful learning: Whose interests are the most important: the teacher's (the system) or the pupils? Every learning situation has to fulfil a purpose! His recipe for successful project work in school is:

"… building bonds such that when certain ideas are present as stimuli certain approved responses will follow. We are then concerned that children get a goodly stock of ideas to serve as stimuli for conduct, that they develop good judgment for selecting the idea appropriate in a given case, and that they have firmly built such response bonds as will bring – as inevitable as possible – the appropriate conduct once the proper idea has been chosen. […] Ideas and judgment come thus. Motive and occasion arise together; the teacher has but to steer the process of evaluating the situation. The teacher success – if we believe in democracy – will consist in gradually eliminating himself or herself from the success of the procedure. (ibid p. 13)"

The long quote feel motivated from the almost poetic description of why the project method is not only beneficial, but also life dependent more or less for the school system. Without a purpose for the learner, the pupils are to get bored and uninspired and, in his own words,

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[2] see for example http://dgwaymade.blogspot.se/2010/10/thorndikes-laws-of-learning-and-its.html for a summary, retrieved 2016-10-17

bring out hate for the content presented. The purposeful acts offer "ideal conditions for forming the necessary habits to give and take." Although there could be situations where coercion is required he considers it "generally a choice of evils." Purposeful action might be considered as coercion when facing more difficult tasks. However, Kilpatrick upholds that a certain stress of difficulty is healthy and can also be necessary to wholeheartedness: The work cannot become routine action from previous knowledge. So the "most educative activity" is when the student work with difficult tasks where the failure not becomes discouraging.

At that time, the projects were considered according to Kilpatrick as four types:

1. *The purpose is to embody some idea or plan in an eternal form: building a boat, writing a letter, presenting a play.*
2. *The purpose is to enjoy some esthetic experience like listening to a story, hearing a symphony, looking and appreciating art work like paintings and sculptures.*
3. *The purpose is to straighten out some intellectual difficulty, to solve some problem like find out whether the dew falls, or why some cities outgrow others.*
4. *The purpose is to enjoy some item or degree of skill or knowledge, as learning to write on a determined level, learning the irregular verbs in French.*

Here it becomes apparent to the main difference between Dewey and Kilpatrick: Although they both embrace the thoughts of education in a social context and project as a perfect form to study, Dewey is more focused on projects of type 3 and Kilpatrick accentuates the projects of type 1 and shows curiosity to develop further a theory of type 2 projects. So in this sense the Kilpatrick contribution is the development on how to define "project" as an educational tool and what approach to use for them. For example, projects of type 1 can be divided into the following four steps of approach: Purposing – planning – executing – judging. For him, the school system has transformed the naturally active child through "aimless dawdling" to "selfish individualists".

Dewey and the Herbartians
Thomas D. Fallace (2011) excellent book on Dewey and the dilemma of race compares (among many other topics) the outdated educational scheme that did not consider biological instinct and inherited impulse discovered in the light of the Darwinian approaches to mind

and behavior. William James had through his work in psychology ("Father of the American psychology") contributed to a more pragmatic view on learning and how school should teach, mirrored through the Herbartianistic steps of learning. (1) The analysis and/or explanation of facts; (2) The synthesis, or assimilation of facts; (3) The identification of the most important facts; and (4) The applications of the learned principles. And yes, this is probably how you experienced your higher education! The content was not only learnt but also "apperceived". Apperception can be understood as the process of perceiving comprehension of something from previous experience. It should promote self-consciousness of and in learning. G. Stanley Hall (see above) and William Torrey Harvis bought the principles of apperception and the concept of correlation between experience and knowledge. Their influence on the American school system, among other renowned philosophers and psychologists, helped the originally German approach from Johann Friedrich Herbart to be established in America. It was a big dispute between leading philosophers and psychologists on the training of the will's existence or not. The Herbartians claimed, like Dewey, that will (and character) is developed through the process, while Harris and Hall, for instance, considered the training of the will to be a central part of getting children ready for learning. Dewey meant that if will and interest were refashioned to "self-expression" they should be viewed as the same thing instead of opposites. Later, Dewey replaced the term self-expression with growth, but the essential meaning was still there. It was merely a semantic change. The main difference between the Herbartianism and other leading pedagogic researchers and Dewey, according to him, was that they put too much focus into the acquisition of content instead of the underlying processes beneath them. You might say that Dewey stepped away from the heritage of Hegeliaism and embraced James pragmatic view on education, but as a pragmatic, he most definitely took the best parts of them all and formed his theory on learning by doing to favor democracy and development of the socially connected content of the participants in his theory on education and instrumental instruction.

Jean Piaget

Further in the development of theories on education Jean Piaget research on cognitive-development processes plays an important role. Piaget studied the cognitive processes rather than taking interest in what was the result of the studying. Because of his focus on the

biological development of man's intellectual maturity, and the fact that Bruner, who used many of Piaget's findings in practical surveys, (see below) is more extensively covered, the thesis does not meet Piaget's work like it (probably) deserves. Since most of the recognized studies on learning from experience came from USA, and the fact that Piaget was from Switzerland, his contributions did not get recognition in the USA until the 1960s. Following the legacy of Dewey and Lewin Jerome Bruner worked with development of curriculum and design on experience-based educational programs and most likely found inspiration from the earlier work by Piaget since many of his experiments were modifications of Piaget's original experiments (Kolb 2014). Since there are many more contributors in the psychological development of experiential learning Piaget's contribution can be summarized like this: He thought that people had a need to understand the world they are living in. Without understanding what is happening around us, it is a risk for mental unhealthy and anxiety. From experiences, we can learn in two ways: Assimilation and accommodation. This means that either we accept new knowledge uncontroversial (no cognitive changes needed), or that in order to gain the fresh knowledge. We need to change our previous understanding. Since experiences are essential to learn more curiosity becomes an important factor for the individual to develop intellectually. The intellective development was divided into four stages:

- *The sensorimotor stage from 0 – 2 years old*
- *The preoperational stage from 2 – 7 years old*
- *The concrete operational stage from 7 – 12 years old*
- *The formal operational stage from 12 and thereafter*

This calls for that there is not much difference in learning from 12 years of age and on forward. It becomes more about finding the right amount of inspiration and constraints (even though this becomes less important with age), overcome your natural laziness and fear from the unknown, setting you in the suitable position to be able to understand the content on what to learn. The ability for abstract thinking comes with the formal operational stage, thinking more scientific where reflections of your own thinking can occur; using hypothetical reasoning and work more systematic (see, for example, Piaget 1976). The four stage model was written as levels of learning and thinking. Biggs and Collis (1982) propose an alternative method to categorize the intellectual development of man, the SOLO taxonomy. According to Pegg & Tall (2005) Biggs and Collis taxonomy focuses on student

response instead of Piaget's; the development of the ability to think and learn. In the SOLO taxonomy it is the students' responses that are important when to develop critical thinking, and they also suggest another level of human intellectual development. Because it starts at about the age of 22, its influences for studies in higher education becomes significant, and can therefore contribute to an understanding of the different levels to the ability to comprehend more advanced mathematical concepts.

The zone of proximal development

In the light of cognitive development and Biggs & Collis distinction from Piaget's four stage model on the ability to critical thinking, there is a natural connection to Vygotsky's theoretical model the Zone of Proximal Development (ZPD). It describes the distance between the student's actual developmental level of problem solving, to the potential ditto determined by the help of expert guidance (Vygotsky used the terms "adult guidance" and "more capable peer"). The theory derives from the fact that you can establish a child's mental age and what she can accomplish under guidance. The gap between the actual mental age and that shown under guidance thus becomes the ZPD. This theory comes from the debate on the relation between learning and development. The (matured) mental development of a child is therefore not the only factor that should be accounted for in determining what can be achieved from collaboration or guidance. Vygotsky suggests that the theory can be a powerful tool in prediction of what knowledge to gain in a later stage, and that "the only good learning" is what already is not learned but within reach, i.e. in the ZPD. This is well in harmony with the proposed use of the revised taxonomy in chapter 9, where various levels of knowledge sooner or later appears less complex due to learning and the reached development. The question to answer (or know) is how much can the student learn, i.e. what are the ZPD at different stages of studying (in higher education)? (Vygotsky 1978)

Guidance – the tutor and the instructor

In the early years, the tutor is your parents and other adults, and the tutoring is more on direct orders or, as developing skills, modeling and imitation (Wood, Bruner & Ross 1976). Although the young child is a "natural" problem solver, the attendance from adults (parents, etc.) helps him on the way (ibid). Are there any differences, or perhaps even more important, similarities between how a child responds to tutoring than an adult in higher

education? This will of course be a question with an answer that can never fully be proofed but consider the following: Young children are heavily dependent on adults simply by the facts that they will die unless someone is caring for them. Furthermore, in the process of learning, the involved adults have a huge impact on what to be discovered except the evolution steps as a human. Learning takes place from curiosity or obstacles that occur and parents (this generalization is used hereon) assist their children with support, encouraging explanations of often quite basic knowledge to be learned. The tutoring takes place either intentionally or unintentionally (modeling and imitation). The process in higher education is actually identical. The instructors are experts in an area to be taught, and the students act from the supervision in the same way, either by assistance in understanding the problem and get an explanation on the problems solving procedure needed, or just listening and communicating with the expert both from lectures and lessons, as well as from the informal talks that occur. Therefore, the interaction with the instructor in higher education outside the structured format is as important for the student as from lectures and lessons, perhaps even more. In building up a relation between humans you learn from each other, and as an expert, you have a huge influence on your pupils. Furthermore, the tutor himself develops from the meetings learning how to approach the students and understand how they think and what is the scaffolds for them to understand the concepts. It is just a matter of level on problems and content to learn; the procedure is still equal: There are facts, concepts and procedures to be learned. What level the problem is at is dependent on a relative state of mind for everyone; for a student near graduation in engineering the problem of solving (decent) linear differential equations is at the equivalent level as solving a linear equation with one unknown variable (preferably "x") at the end of a science program in Secondary school. This will be further investigated and explained later in this thesis, see the section on Bloom's taxonomy and the published papers in chapter 8 and 9

Jerome Bruner

Bruner grew up when Dewey, Lewin and Piaget published their work. He was involved in the major revision of teaching in primary and secondary school and its influence on higher education that started in 1959 when the fear from losing distance to the Russians in the conquer of space creating almost chaos in the political and school system, of course colored from the communist fear ("Red Scare") that was apparent in the USA in the fifties. The

revision of the scholar system took off at a conference at Woods Hole on Cape Cod ("the conference") where 35 scientists, scholars and educators discussed how education in Science could be improved in the younger ages. During the meeting, the following five work groups were founded:

- *Sequence of a curriculum*
- *The apparatus of teaching*
- *The motivation of learning (including Richard Alpert and Kenneth W Spence)*
- *The role of intuition in learning and thinking (including Robert M Gagne, George A Miller and Jerrold Zacharias)*
- *Cognitive processes of learning (Bruner and Francis Friedman)*

Bruner was assigned chairman of the executive committee that coordinated the work at the conference. He then published the outcome from the conference and the complementary work in The process of education (1960). From the foreword he states that the report is perhaps not the consensus of a new approach to teaching and learning, but more a "sense of the meeting". You can consider this ambitious task as the first real attempt to revise and design a scholar system in the aftermath of the great philosophers Dewey, Lewin, Piaget and others. Personally he found it rather amusing to see the great minds and their efforts partly conclude with the moon landing in 1969, but partly even create a mathematic curriculum, "New math", for the younger age that created mathematic confusion and did not provide any improvements and was abandoned already in the 70s. Since the interest of this text is not exactly what they came up with in detail, but more Bruner's view of the outcome interested readers can read Robert Ulich's *Three thousand years of educational wisdom* (1959). Bruner, although not making references, shows from the start experiences from the earlier work by Dewey and his critique of the traditional educational system Dewey experienced and acted on:

> *Clearly there are general questions to be faced before one can look at specific problems of courses, sequences, and the alike. The moment one begins to ask questions about the value of specific courses, one is asking about the objectives of education. The construction of curricula proceeds in a world of changing social, cultural, and political conditions continually alter the surroundings and the goals and their students. […] Moreover, schools must also contribute to the*

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social and emotional development of the child if they are to fulfill their function of education for life in a democratic community and for fruitful family life. If the emphasis in that follows is principally on the intellectual side of education, it is not that the other objectives of education are less important (Bruner 1960 p 8f).

Further he states that although the most general objectivity of education is to schooling the better student and also "helping each student to achieve his optimum intellectual development", "Good teaching" is primarily for the "less able" student. They are the first to lose track by poor teaching.

The conference presented four themes for the process of education:

- *The role of structure in learning – learning (and teaching) is about understanding in what context the content of the subject is presented, not just learning to master facts and techniques (i.e. the same as facts, concepts and procedures later presented). So the relations between what is already known and what to be learn helps creating a general picture of the field as clear as possible. At the time not much was known in this field so much of the time was spent discussing how to provide learning conditions that fostered the students (and teachers) to learn (teach) fundamental structure.*

- *Readiness for learning – based on the hypothesis that "any subject can be taught effectively in some intellectually honest form to any child at any stage of development."(ibid p 33) The general opinion was that many important subjects were postponed from teaching because schools found them too difficult. So the consensus was that the basic ideas and themes of all science and mathematics were simple enough to be taught. So the curricula should consist of concepts for understanding, not learning difficult applications out of reach for the young child. The learning should focus on the child's intuitive ability to adapt phenomena without presenting the theory behind it. The approach is closely related to Dewey's, Lewin's, Piaget's and Kolb's for that sake spiral of learning through process and experience, and is also called the spiral curriculum.*

- *Intuitive thinking – "the shrewd guess, the fertile hypothesis and the courageous leap to a tentative conclusion" are the most powerful assets for the learner, no matter what subject or interest. How can school nurture this ability was being discussed.*

- *The three themes above are all premised that there is intellectual activity and an urge to learn. Therefore the last theme relates to the desire to learn and how to stimulate interest for the subjects taught.(ibid)*

There was a consensus on that teachers were the principal agents of instruction, not teaching devices. Therefore, the teacher him- or herself was the only authority in deciding what to be learn and how to present it, and that there was no best way in using visual and practical aids in the process of learning.

Bruner's theory of instruction

Since Bruner became the philosopher who somewhat concluded the work from the early philosophers from 1870 and onwards, and was the Director of the Woods Hole conference, his theory of instruction becomes even more interesting. In parallel to Bruner's theory, Kolb's work towards Experiential learning theory (ELT) began and is covered further down in this book in relation to Problem and project-based learning (PBL). Bloom (1956) had presented his Taxonomy of educational objectives but was (rather surprisingly if you look into the impact he had) not among the learning experts who were invited to Woods Hole in 1959. Bruner considered Piaget as "the most impressive figure in the field of cognitive development today" (Bruner 1966, p. 6f), and lots of his experiments on younger children had its origin in Piaget's work. From numerous tests in his laboratory on children he thinks "that the heart of the educational process consists of providing aids and dialogues for translating experience into more powerful systems of notation and ordering." Therefore, a theory of development needs both a theory of knowledge as a theory of instruction (ibid p. 21). The linkage to Dewey, Lewin, Vygotsky and Piaget is apparent and imbues his whole practice of education and instruction. Why the need for change then? Almost a decade of research and great minds in educational psychology passed so clearly some effect on the scholar system must have occurred? Well, according to Bruner the psychologists in education and learning were not much recognized, even diminished, since the focus had been on learning and learning in created environments. The contribution to educational practice was considered slim. The teachers lacked a clear strategy on using the new knowledge on learning. A Theory of instruction was missing! In short his theory:

- *It is normative and shall improve your teaching and tutoring.*

- *Specify the experiences that are the most influential for the individual on what to be learned.*
- *Find an "optimal structure" for the content.*
- *Specify the most effective sequences of the presentation of the material*
- *Pace the rewards and punishments in the process*

Not surprisingly he highlights the planning and development of all "curriculum materials". It is all about preparation; in the classroom, you are who you are and act according to your insights from the preparation stages. You must wonder if this book, printed six or seven years after the conference in Woods Hole, somewhat was a reaction from the fact that all the focus at the conference included what to be learned and how, leaving the educator on his own in interpreting and teach what has been reported from the specialists. Just a thought! Since knowing is a process and not a product, it is actually wrong to exam more explicit complex procedures in higher education, unless the concept of the procedure brings something for the student. Therefore, remembering facts and procedures that can be looked up seldom covers the curriculum as exam problems. Many course aims are conceptual and the exam should mirror that. Intellectual development depends on the interaction between the learner and the tutor (ibid p. 6). So the process at hand to provide is how to get the students to communicate in the learning process. The problem with a voluntary education system in higher education becomes apparent: Shall an extrinsic motivator be forcing the student to be present whenever learning environments are scheduled? Or is it simply the student's own responsibility to understand that he/she shall attend? Is this something to be learned from very young ages explicit in terms of the curricula? How do we put attendance as a learning goal to be examined in higher education? Is that what we should strive for to help students finishing their exam? Can a learning goal make the students work closely together and towards the instructor and the tutor?

As seen from Dewey and Lewin Bruner is also emphasizing the relations as the utmost important ingredient for intellectual growth and a necessary condition in the learning process, whether it is between the student and the tutor or between the students. To rescue "the phenomena of social life from familiarity" Bruner suggests four techniques:

- *Contrast as an important factor in establishing conceptual categories. The principal sources from contrast are man versus higher primates, man versus prehistoric man, contemporary technological man versus primitive man, and man versus child.*

- *Stimulus and use of informed guessing, hypothesis making and conceptual procedures.*

- *Participation, particularly by the use of games that incorporate the formal properties of the phenomena for which the game is an analogue. The game becomes a mathematical representation of the reality.*

- *Stimulating self-consciousness. (ibid p. 92ff)*

The "threat" from social studies becomes familiar is the difficultness to see a generality in what becomes familiar. An example on creating self-consciousness to help thinking in new ways is Richard Crutchfield's using of a series of comic books where the reader (the child) is stimulated to use clues cleverly to solve the mysteries from clues the detective exploits implicitly.

When Bruner presents an example of a model for learning language, the top-down perspective is clear: To keep interest the assignment has to mean something and be "useful"; in this case five word sentences that tell a "story". From that structure, new sentences can be formulated and constructed, and then the different parts can be categorized and explained. So Burner understands and presents the top-down perspective, although not in direct words, and that you have to develop your own practice from a very well prepared curriculum. Between the lines, there are a concern and worry for the new content in subjects from the Woods Hole conference (at least a qualified guess).

Bruner highlights five ideals achieved if the planning and teaching are totally successful:

1. *To give our pupils respects for and confidence in the powers of their own mind.*

2. *To extend that respect and confidence to their power to think about the human condition, man's plight, and his social life.*

3. *To provide a set of workable models that make it simpler to analyze the nature of the social world in which we live and the condition in which man finds himself.*

4. *To impart a sense of respect of the capacities and humanity of man as species.*

5. *To leave the student with a sense of the unfinished business of a man's evolution. (ibid p. 101)*

In the perspective of Bruner and his theory for instruction, firmly attached to the legacy of Dewey, Lewin, Piaget and other great social scientists, the teaching role can be considered as a function from a whole new perspective, definitely not the person facing the students in the classroom. In fact, calling the person in direct contact of the students a teacher is misunderstanding the learning that takes place in organized education. The teacher is a collection of functions in the process of creating courses and programs and to cause learning environments. The instructor and tutor are two functions of the teacher, the planner and developer of the curricula others. The board of the educational institution as well as the administrators is also a part of the teacher. Is it really that wrong to call the instructor and the tutor for a teacher? It is a simple fact that you cannot teach anyone anything that is learned; the process of learning is always in the student's mind. Therefore, no teaching can guarantee learning so the learning process can merely be accomplished by communication and creating learning environments that helps the student find motivation and explanations from their experiences to come up with new facts and concepts, and procedures based on the fresh understanding. This is well in harmony with the theories of Bruner that the preparation work for the instruction and tutoring is the most important. This explains perhaps also the failure of the change in curriculum proposed by the teaching experts in Woods hole: They forgot, or did not realize, that the learning part was to be led by teachers who were not simply educated in what the developed curriculum was about. The theory of instruction was not explained, probably because they have not understood the complexity of the institutional change the content needed. The new curricula was simply interpreted from their previous experiences and put into the "one school system", and the individual prerequisites were not taken into consideration, neither for the teachers, nor the students.

Blooms (revised) taxonomy

In the 1950s Benjamin Bloom presented his taxonomy of educational objectives for learning. He categorized the reasoning skills required in the classroom in six levels:

- *The knowledge level is about memorizing facts and simple procedures.*
- *The comprehension level is about understand and interprets your knowledge.*

- *At the application level you can use, or apply, your knowledge to solve and examine problems.*

- *In the analysis level, students will be required to go beyond knowledge and application and actually see patterns that they can use to analyze a problem.*

- *With synthesis students are required to use given facts and concepts and be able to apply knowledge from other areas to understand and create other or similar problems,*

- *At the top level, evaluation, students are capable of using knowledge and assess the effect of it.*

The point for you as a teacher was to attempt to move the students through the taxonomy in the progression of their knowledge. This was an attempt to guide teachers from not just examining and assesses knowledge learnt by heart, but to create thinkers. A handbook was also produced in how to use the objectives. In the handbook, the six categories were divided into three domains, cognitive, affective and psychomotor. In practice this was hard to apply, and the most common approach for testing became a simplified version where three levels of questions were assessed: Knowledge, comprehension (apply routine solutions on problems) and problem solving using existing knowledge and skills to situations not known before (see, for example, Buckwalter, Schumacher, Albright, & Cooper, 1981). Rinchuse & Zullo (1986) found that almost all the examination questions (86%) on a pre-doctoral school for dentists came from the first category and the rest from the second. In Buckwalter et al (1981) they refer to other cognitive taxonomies such as that from Christine McGuire (unpublished 1973) (three levels), and L. Hilsenrad & K.S. White (unpublished 1975) consists of four levels.

The proposed taxonomy was far from uncontroversial and tested and questioned by many. However, the empirically test by Kropp and Stoker (1966) supported the validity of the hierarchal structure and the impact on teaching, and the categorization of educational objectives cannot be argued against. Furthermore, the process of the taxonomy has to be taken into consideration: Although many years of testing and numerous iterations towards teachers were made, there are no ultimate solutions for educational objectives, merely attempts to create functional systems that work in the designated environment. Therefore, parallel taxonomies can and must exist since they are dependent on the environment they

are supposed to function within. Even a specific taxonomy such as Blooms has to occur in various shapes depending on the situation it is applied to. It is not this books intention to compare different taxonomies and weigh their advantages and disadvantages against each other. Instead take into account what is suggested by research and other theories, add experience and from there creates a system that works and makes sense. This point of view is also supported by Seddon (1978) in his meta-analysis of the educational and psychological properties in regard of the taxonomy. Seddon states further that future experiments should focus on finding the taxonomy that best facilitates communication. Williams, Snowman and O'Hara (1979) suggests two categories instead of six; concrete and applied intelligence. Seaman (2011) considers them to be "different words expressing similar concepts".

The revised taxonomy in 2001 (Andersen, Krathwohl & Bloom) was an upgrade due to the society's values and knowledge base had changed. In their attempt to "incorporate new knowledge and thought into the framework" (from the foreword) the taxonomy was complemented with the knowledge dimension: facts, procedures, concepts and a meta-cognitive level. The six categories were also updated as verbs instead of nouns: application became apply and so on. One big difference is that the cognitive dimension was now not considered as a sequence of the different levels. The approach was to highlight them from the complexity that was experienced from the curriculum's view. The inward sense was to help the teacher to categorize the course aims to a spot in the taxonomy table, and from there better be able to assess the specific learning goal. This is well in harmony with considering all knowledge to be circumstantial and relative to its learners and was the basic idea behind the attempt to present all knowledge to be learn from the understand and apply level of the knowledge dimension. Dewey also referred to the outcome of his suggested processes as facts, i.e. all that is known can simply be looked upon as facts, see paper 4 in chapter 9.

A review of the revised Bloom taxonomy in a top-down approach perspective
From paper 4: Computer-aided simulations help the students to test the components in circuits much more time efficient than on the circuit board in the laboratory. The use of simulation of circuits in the context of theory and measurements gives the students a better understanding of the theory and motivates the students to use simulation software to analyze and design electronic circuits (Li and Khan 2004). Baltzis and Koukias (2009) shows

that the use of laboratory experiments and IT tools permits the students to acquire advanced knowledge and skills to develop realistic electronic systems and computer simulations, which proves to be highly beneficial in later courses. This calls for an early introduction of a method on how to attack electronic problems that is preferably used for the whole program, providing continuity in the practice. In comparison with an approach trusted in traditional lectures and PBL as the intervention in teaching, students in a PBL approach learned twice as much in comparing conceptual understanding of the tests (Becker, Plumb and Revia 2014). Assuming knowledge is holistic, Carstensen and Bernhard (2008) suggest a new model of complex context to identify and clarify `the troublesome elements´ of the threshold concepts. In the model they identify `the pieces´ of the threshold concept to learn and find the links between the pieces to establish knowledge relations. They discuss further and suggest three fundamentally different modes into investigation of threshold concepts: How to recognize a threshold concept? In what ways is it difficult and troublesome? And how do we find the critical aspects? They build their categorization of knowledge on Vince and Tiberghien (2002) that suggests a linkage between *Theory/model world* and *Objects and events world* where the learning is defined as skills, abilities, declarative and procedural knowledge. Carstensen and Bernhard (2009) use the presented method in an electricity circuit course using variation theory for the tasks and the analysis of the task structure. That study is therefore not similar to this but still interesting because although they changed just one primary parameter at a time, several changes in the system's response could occur. In their conclusions their results indicate that the theory of variation can be useful when designing new learning environments and to improve existing ones, to learn more complex concepts. This could well be adopted in the process of this study. In 2001 Andersen, Kratwohl and Bloom published their revision of the taxonomy of educational objectives by Benjamin Bloom (1956). The original taxonomy defined six major categories in the cognitive domain: knowledge, comprehension, application, analysis, synthesis and evaluation. All but application were broken down into subcategories. The categories were arranged from simple to complex and from concrete to abstract. To advance in the cognitive domain you had to master each of the simpler categories. The taxonomy was adopted by many and was used to classify curricular objectives as an example. In the revision the one dimensional taxonomy was extended with a second; the knowledge dimension. The categories are facts, concepts, procedures and a metacognitive level. Basically the

knowledge dimension highlights the nouns of knowledge and the cognitive the verbs. Therefore *application* became *apply*, *analysis* became *analyze* and so on.

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual						
Procedural						
Metacognitive						

The level of complexity and the kind of process decides where each learning objective ends up in the table. The table then gives an indication of how difficult the content is. It is an attempt to categorize knowledge and it helps you understand the nature and complicity of your learning objectives. Originally the taxonomy described the steps needed to understand a problem/area. The different types of knowledge were introduced to include learning goals for a course, and the writers carefully explain how to analyze your learning goal and where it will end up. The problem is partly to rank the learning goal, and partly how to get there with your teaching. Learning goals can, however, contain both procedural and conceptual knowledge; sometimes it is possible to reach the learning goal in both these ways. It is all about how you choose to grade the knowledge. In a written exam it is quite possible to solve a problem in more than one way; one can be strictly procedural while the other using concepts, or a mix in between.

According to Amer (2006) Furst (1994) noted a weakness in the assumption that the processes were ordered on a single dimension from simple to complex. The notation was made in the perspective of that the next stage of complexity was dependent on all the previous, i.e. a cumulative hierarchy. Kreitzer & Madaus (1994) draw conclusions from empirical studies that the hierarchical structure of the taxonomy was not valid: Knowledge can be more complex than Analysis and Evaluation, Evaluation is more complex than Synthesis and Synthesis involves Evaluation. So the taxonomy was perhaps not valid in a general sense but still an important approach to understand the complexity of learning and learning goals for the students. New theories and approaches to learning were introduced after the publication of the original taxonomy which makes the student more aware of their

own cognition and thinking: Constructivism, Metacognition and self-regulated learning (Amer 2006). According to Amer, Constructivism assumes that the students must discover, construct and transform knowledge to make it on their own. Self-regulated learners have the ability to use skills, knowledge and attitudes to develop new knowledge and skills to be "self-going." This is most likely what the meta cognitive level in the revised taxonomy stands for. It is though not far to assume that the original taxonomy explains the knowledge chain for a well-defined skill unadorned. A way of describing how the learning of our brains works in specific situations, not necessary how all the knowledge must be learned. In the 1950s it was a practical approach to set the curriculum in a learning perspective to understand why some assignments and tasks are harder than others. When analyzing students' knowledge, the ability to analyze and synthesize based upon their knowledge and comprehension of a field/subject/learning goal becomes a sound way to grade. From the research on understanding and the new developed theories on teaching and learning the taxonomy suddenly had lots of more data to consider and called for a more general revision. All previous users of the original taxonomy had to revise it in their practice to fit their curriculum. When doing that the grading becomes more or less from the taxonomy. So the interesting part is hardly to find faults and flaws with the taxonomy, but to develop the proposed categorization of knowledge.

Considering the two dimensions of the revised taxonomy it becomes easier to formulate the objectives of a course: The knowledge dimension describes the category of knowledge, and the cognitive dimension the complexity. However, since all learning is circumstantial and relative to prior knowledge you can probably sort out a more complex subject or content in "simpler" steps to reach the same understanding, as proposed in chapter 9. As Carstensen and Bernhard (2008) have pointed out there are thresholds in the process of learning on an engineering program, but the more knowledge and experience you gain, what once was considered really difficult and probably at a "high level" in the revised taxonomy, most likely is almost trivial later. So for a description at a time dependent and planned program the taxonomy's two dimensions will be marked in the majority of all squares, but for the experienced engineer, the knowledge from the curriculum to be gained is to be found in the Remember, Understand and Apply squares of Facts, Procedures and Concepts.

You might not like the categorization of the presented taxonomy and find some support in research. This text's intention is not to present a "for and against debate" and find pro's and con's for each eventual side. From the reasoning above and the spirit of the whole thesis there are no correct methods or answers in psychology based subjects and fields, just theories and methods with different validities depending upon its context. Whatever method or theory you use you must analyze and plan for how it is to be used right there. If you are supporting the view of the taxonomy, or some other for that reason, or not does not really matter: As an educator who constantly evaluates and tries to better your practice you will still analyze and interpret the content and use to your own standards. Therefore the use (or not use) of any reference must undergo the process of evaluation on each practitionist, if you are a firm believer of Dewey and learning by doing. This fact makes all inputs, whether they are "correct" or not something you always consider and interpret from your knowledge and experience. It is possible to categorize knowledge and try to make it general, but sooner or later it has to be subjective to one's practice.

David A. Kolb

In his monumental work on Experiential learning Kolb summarizes his experiences inspired from the "prominent twentieth-century scholars who gave experience a central role in their theories of human learning and development": Dewey, Lewin, Piaget, Lev Vygotsky, William James, Carl Jung, Paolo Freire, Carl Rogers and Mary Parker Follett. He discovered an intellectual perspective on human learning and development that is both pragmatic as well as humanistic. Kolb's major contribution is the overall systemization of the learning by doing concept based on experiential learning and adaption to a more modern system of education. If you are a bit mean, you might say that nothing new has come out from the work of foremost Dewey, Lewin and Piaget, but nevertheless, he theorizes the whole concept and, in an American way perhaps, launches the ELT concept and his learning styles (LSI=Learning Style Inventory) in a sellable package. Putting the mean part aside the perspective all the way towards higher education and its application of experiential learning theory on teaching and administration is still a great contribution in the field. The author's first experience from Kolb's work came from an LSI test in the early 90s where the learning style was decided and related to Jung's psychological types. The result felt satisfying and apt so a study of Kolb's

Experiential learning (1984) led to the description of the learning styles from the LSI (p. 114f):

- *The convergent learning style relies primarily on abstract conceptualization and active experimentation. This person does best on conventional intelligence tests where there is a correct answer or a solution to a problem. Knowledge is organized through a hypothetical-deductive reasoning.*

- *The divergent learning style is opposite of the convergent and emphasizes concrete experience and reflective observation. The imaginative ability and awareness of meaning and values are the greatest strengths. An ability of divergence is to view concrete situations from many perspectives and bring meaning to them. The brainstorming session is a typical environment that suits the divergent learner.*

- *If your dominant learning abilities are abstract conceptualization and reflective observation, you belong to the assimilated learning style. The strengths lie in inductive reasoning and the ability to create theoretical models. The person is mainly concerned with ideas and abstract concepts rather than people. It is more important that the theory is logically precise rather than useful or practical.*

- *There is an opposite to the assimilate learner as well: The accommodative. This style is best suited for situations where one must adapt to changing of immediate circumstances. It is thus an adaption to situations where the theory or plans do not fit the facts. The intuitive trial and error-manner is well suited for this style.*

From Jung's psychological types in the table below Kolb suggests a relation between them and the basic learning styles above.

Table 2 – Table 4.2 from Kolb (2014 p. 117)

Mode of relation of the world	E EXTROVERT TYPE	I INTROVERT TYPE
	Oriented towards external world of other people and things	Oriented towards inner world of ideas and feelings
Mode of decision making	J JUDGING TYPE	P PERCEIVING TYPE
	Emphasis on order through reaching decision and resolving issues	Emphasis on gathering information and obtaining as much data as possible
Mode of perceiving	S SENSING TYPE	N INTUITION TYPE
	Emphasis on sense perception, on facts, details, and concrete events	Emphasis on possibilities, imagination, meaning, and seeing things as a whole
Mode of judging	T THINKING TYPE	F FEELING TYPE
	Emphasis on analysis, using logic and rationality	Emphasis on human values, establishing personal friendships, decisions made mainly on beliefs and likes

Later the learning styles have been revised after critiques and debates on the validity (Sternberg & Zhang 2014).

There are now three dimensions in the model so the learner takes three spins in the process of learning by experience:

Table 3 - The process of learning by experience

Learning styles	Developed modes	Underdeveloped modes
First-order learning styles		
Diverging	CE, RO	AC, AE
Assimilating	AC, RO	CE, AE
Converging	AC, AE	CE, RO
Accommodating	CE, AE	AC, RO
Second-order learning styles		
Northerner	CE, RO, AE	AC
Easterner	CE, AC, RO	AE
Westerner	CE, AC, AE	RO
Southerner	AC, RO, AE	CE
Third-order learning styles		
Balanced profiles	CE; AC, RO, AE	None

AC= Abstract Conceptualization, AE=Active experimentation, CE=Concrete experience and RO=Reflective observation.

So Kolb's learning styles is about perceiving and processing. There are more recent studies and theories on learner styles, many of them connected to interactive learning from the internet, mostly based on qualitative inquiries which makes them no less interesting, but as a framework from educational theories based on active (doing something else than just listening) learning from experience and intrinsic motivation, nothing compares to Kolb's work. The connection between learning styles, whoever you use, intrinsic or extrinsic motivation and deep and surface learning is apparent and of greatest interest. In this book the strive for intrinsic motivation based on your own experience and knowledge to promote deep and achieving learning (Biggs 1987) is the chosen perspective based on, that's right, knowledge and experience from 27 years of teaching and 47 of conscious learning.

In Kolb's work on experiential learning theory the importance of scholars like the ones above is mentioned and frequently referenced to. Carl Rogers (1964) in particular has influenced him through very direct and clear conditions for learning and change for the individual:

1. *Experiencing is central*
2. *Unconditional positive regard, respect and psychological safety for everyone*
3. *The development towards self-actualization.*

The author of this thesis has not found himself comfortable in any special learning communities; he thought he fitted in most learning environments understanding more than most of his fellow students and experienced an ability to solve most of the problems and tasks presented for him. The outcome from the LSI test proved him right to that he found himself near the middle with a slight tinge towards assimilation. For an assimilator he had a strong influence from the accommodative side. This harmonized well with his feelings since he from his early years always been interested in finding theories behind what he knew and learned. The appreciation for confirmation of his thoughts in real life helped him keep the curiosity reflecting on sensations he met. The need for setting up experiments to find out new relations had never been there, merely the satisfaction from being curious on what occurred around him and ask or looking for answers of the experienced or observed phenomena. From the researcher's perspective Jung's psychological types did not trigger him but the fact that the students have different abilities to learn and to function together gave inspiration to relate to the Problem based learning (PBL) model. Clearly there are connections between Dewey's learning by doing theory and Kolb's categorization of learning styles, and the grouping process thus becomes interesting. Studying and working in a University informed by a "chalk and talk"-culture, the students were left alone organizing their learning and the (lack of) communication in the classroom was often mentioned during coffee breaks and lunch between the colleagues. Many times the informal discussions on students' interaction with the lecturer ended in a curse over their inability to participate and keep up with the intended planning of the curriculum. Since the only motivation was the interest the lecturer created in the classroom it became even more important to keep the information and planning of the courses crystal clear. Not surprisingly one of his inquiries revealed that courses where the students early knew what to learn and how the exam was inclined were considered the most appreciated ones.

Other learning styles

Although Kolb's learning styles are derived from the Experiential learning theory and all the way back to Dewey, learning by doing, Lewin and Piaget, and project based learning, there

are of course other theories on learning styles. The Honey-Mumford Model (Pritchard 2009) presents the following:

- *Activists – prefers learning by doing before reading and listening and is driven by "give it a go", if it works it works, otherwise just try again.*
- *Reflectors – the observer. Collects information until a picture of the whole is made. Analysis the information from previous and known knowledge and their own experience.*
- *Theorists – Seeks for relationships on their observations and information at hand. Questions new information to reach new understanding.*
- *Pragmatists – Wants to know how they can use the new knowledge presented or gained. If they cannot find any use of something it is not worth remembering.*

Neuro-linguistic programming, NLP, is developed from the relationships on how we communicate with each other affects our learning. Three particular learning styles come from this practice:

- *The visual learner – Prefers learning by observing and watching*
- *The auditory learner – Prefers learning by listening and discussing.*
- *The kinesthetic learner (or kinaesthetic as Pritchard spells it) – Prefers learning by doing*

Later (Fleming 2001) the NLP description on learning styles was complemented with the reading learner, thus becoming the V-A-R-K-system of learning.

There are numerous of other theories, for example the Myers-Briggs model, Kolb has been presented, Felder-Silverman**,** and all of them have at least one thing in common: They come with a tool of testing to determine what kind of learner you are, probably to make some cash out of their classification of learning. Much focus is on determining learning styles and how useful it is to understand your student. A reflection that highlights the difficulty in practice when meeting maybe 20-40 and up to more than a hundred students daily to remember partly the learning type, partly set them into the social context of the actual meeting, calls for a little bell ringing that perhaps the determination of learning style is more for the learner (and fun) than the instructor and the actual course!?. Naturally it is interesting for each human to know how they learn best, if a test and/or a model now are

the most appropriate way to determine that. There are also scientific issues in believing that different learning styles as, for example, Visual learners should learn better from a certain instruction.[3] Pashler, McDaniel, Rohrer & Bjork (2008) found no evidence that a preference for a learning style gives better learning, mainly because of the lack of research on such action. According to them most of the learning styles lacks the necessary experimental studies to testing the validity applied to education. We function differently in unlikely environments, both because of the social interaction but also in what comfort zone the actual place and situation set us. Looking back at Piaget and Vygotsky where Piaget stressed the inner motivation to reach new understanding and knowledge, and Vygotsky stressed the importance of social interaction for the individual, you are still at the two main components of intrinsic motivation, and implicitly learning through action (or active learning) to learn more effectively.

Active learning - Inductive and deductive teaching and learning

What makes learning active? How can learning to be passive? There is not obvious what you mean in the context of active learning. Learning from Dewey and the social scientists of the late 19th century and early 20th concludes that in what context and to whom the curriculum is presented to play a crucial, not to say decisive, part of the process and how the intrinsic motivation is nurtured. It is as easy as looking back on the nine years of primary school and the nearly total neglect on the children at hand to understand that the theories have not been accepted. As Shernoff (2013) also noticed the one school system is not the solution for intrinsic motivation, but still it exists and dominates without noticeable connection to attendance: the curriculum on what to learn is far more important than who are the learners. The obvious lack of proper context prohibits students to have a clue on what they learn and a sound recollection of the meaning in general on concepts can therefore get lost. During the 1950s and the 60's curricula's changed to support more inductive learning strategies, like, for example, Bruner suggested and was a fan of. Although Dewey was a firm believer of the more student including teaching strategy, the instruction was heavily dominated by a teacher lecturing well known structures of procedures used, regardless of

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[3] http://www.psychologicalscience.org/news/releases/learning-styles-debunked-there-is-no-evidence-supporting-auditory-and-visual-learning-psychologists-say.html

their utility in real life. The students were then supposed to learn exactly what been taught, and the exam left small or no room for critical thinking and creativity.

Deductive and inductive teaching strategies come from 'deduction' and induction'. Deduction means that the whole is broken down into subparts and logic reasoning is used to form the whole, while induction considers special cases that can form a general conclusion. Deductive teaching (and learning) is therefore a bottom-up approach where the bits and pieces are described in how to create a whole. Inductive teaching assumes an actual event or experience and explains the content from there; i.e. a top-down approach. From the Merriam-Webster dictionary inductive is explained, "using particular examples to reach a general conclusion about something", and deductive "using logic or reason to form a conclusion or opinion about something". So inductive learning is about understanding a concept and its use in other contexts. In inductive learning you draw conclusions from observed data and try to make a more general statement. An example could be learning Ohm's law from a series of simulations on electrical circuits with resistive impedances. Measuring voltage and currents through them should motivate the validity of Ohm's law. Deductive learning builds up a theory or a concept from logical reasoning and facts. Euclidian geometry is an example. Simply with the help of a ruler, compasses and some axioms the theory is determined. From Felder and Silverman (1988) came the introduction of the inductive/deductive dimension of a learning and teaching model. In their paper they argued for the inductive form of learning. This was later dropped by Felder since he noticed that the students preferred the deductive approach in front of the inductive because then it was obvious what was taught, and the conclusions were proven. The latter approach was more connected to the senses of human, more in particular the Visual, the Auditive and the Kinesthetic. Although this was mostly from an engineering education perspective, the preference on how to learn more effective can be closely derived through the senses of watching, hearing and touching (working with your hands) something. The conclusion to drop the more inductive format of teaching is supported in this thesis data. This makes the problem of introducing more student active learning much more complicated, as further discussed below. There is no guarantee that students will prefer more active learning facilities when the changes are on a course here and there. To succeed and build for a more inductive approach that most certainly will lead to deeper learning, the change must be

more institutional. Each of us can make an impact by our own good example, but an institutional change requires so much more. To understand more on these thoughts, see the section on the definition and analysis of the teacher's role in chapter 10.

Other learning strategies than "learning by doing" (i.e. micro teaching)

Bruner (1959) makes a digression and comments on the upcoming computer aids ("automatizing devices, teaching machines", p. 83) and its use in education:

> *Perhaps the technically most interesting features of such automatic devices are that they can take some of the load of teaching off the teacher's shoulders, and, perhaps more important, that the machine can provide immediate correction or feedback to the student while he is in the act of learning. It is still far too early to evaluate the eventual use of such devices, and it is highly unfortunate that there have been such exaggerated claims made by both proponents and opponents. Clearly the machine is not going to replace the teacher – indeed, it may create a demand for more and better teachers if the onerous part of teaching can be relegated to automatic devices. Nor does it seem likely that machines will have the effect of dehumanizing learning. A program for a teaching machine is as personal as a book: it can be laced with humor or be grimly dull, can either be a playful activity or be tediously like a close-order drill. (ibid p. 84).*

Bruner shows a great nose for the opportunities of new learning environments in this pragmatic prediction of the computers' role in education. Probably in the backwash from the focus that the conference in Woods Hole provided, as well as the highlighted use of the early philosophers' work on learning from experience and the need for change of the one school system: the students had to be considered more as contributors to the teaching and learning, instead of just targets for information on what to learn. The active learning approach was more in focus, although all learning is of course active, but the methods focused more on how to appeal to the learners and find an intrinsic drive towards learning. A definition for active learning was proposed by Prince (2004) as any instructional method that engages students in the learning process. So active learning shall trigger students to meaningful activities that promote critical thinking. This definition is in contrast of the more

traditional lectures where students passively receive information from the teacher. Student active learning models have been established such as collaborative learning, cooperative learning, problem based learning, CDIO (Conceive – Design – Implement – Operate) and so on. They all have the focus on group work in common.

Micro teaching became popular in the 1960s as a teaching method where normally the procedure was like a scaled-down teaching for a maximum of 15 minutes in front of a small group. This was originally a method mostly for teachers to evaluate their practice, as a part of the education for future teachers (Brown 1975). Although micro teaching was originally constructed for real classroom teaching, the transition to a computer-based forum for learning is not far away. Especially if you consider Bruner's thoughts about the use of the computer aids he predicted.

In mathematics-based courses, for example in engineering and physics, lots of valuable classroom time is spent on explaining new facts and simple procedures to understand the concepts and more complex procedures that are the course aims of the actual content. An exposition of basics is often informative and does not stimulate much interaction in the lecture hall, time that could better be used to describe phenomena based on the new facts and simple procedures if they already were known. So by preparing necessary knowledge of these basics in advance and post them online would benefit the communication and interaction possibilities in the classroom or lecture hall. This frees valuable time to find learning environments that start the process to interact with the students and better understand their experience entering the new field of knowledge. When using this rather simple method of online lectures it is as easy to create a forum where they test if they have understood the knowledge presented. The origin of computer-based aids promoting micro lecturing and tests online such as Scalable learning, Moodle, Claroline, Udemy, RCampus, Learnopia, and P2PU[4] , most of them free of charge and use, have exploded and is obviously growing in popularity among teachers. The primary use of them is to publish online lectures and tests for the students, often combined with a chat forum for the possibility to interact with the teaching staff. The possibility of communicating via the web also provides the teacher with an improved understanding of what are the issues and thresholds of the new

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[4] http://www.freetech4teachers.com/2011/02/seven-free-platforms-for-teaching.html#.V-Pbrq252-s retrieved 160922

content, and can therefore better calibrate the level on the more conceptual teaching live with the students. A modern term for the concept is Flipping the classroom, see chapter 8.

From chapter 9, clearly simulations on electrical circuits improve the ability to learn more and more conceptual. Often in mathematical based subjects the problems consist of an understanding part of a concept and a procedural way to explain properties and use of the concept. Since many students find the math troublesome, the complexity comes partly from learning the calculations and partly from understanding the concepts. Carstensen and Bernhard (2008) suggest three fundamentally different modes to investigate and understand the threshold concept's students' experiences:

- *How to recognize a threshold concept?*
- *In what ways is it difficult and troublesome?*
- *How do we find the critical aspects?*

They present their model to find the troublesome elements of the threshold concepts and uses variation theory as a learning aid testing the model in an electricity circuit course (2009). If you as a teacher or instructor are able to answer these questions you have a model to evaluate the concepts and procedures of the content, not only in a similar course they used it in.

Learner-centered model

Good teaching in higher education can thus be as simple as to present interesting material in a well-structured curriculum. These method trusts in a competent teacher giving informative lectures and lessons as the key to learning for the students. The motivation is the students' desire to complete the course and move on in the program towards graduation. Without any reference or supporting data, it is easy to suspect that these courses consist of standardized tests where the students have collected previous exams and solutions to help them to pass the exam. The premise of a learner-centered model is the perspective that couples a focus on individual learners with the focus on learning (McCombs & Whisler, 1997, p. 9ff). Focusing on the learner is inductive and focus on the content is more deductive. Lambert & McCombs (1998 p. 4) states: "Goals for education that assure an optimum education for all children require the achievement of learning goals for every child.". Their book on How students learn gave him an insight into the development of active and experiential learning

from Dewey and on-forward. "No act can be understood apart from the series from which it belongs" (Dewey, Hickman & Alexander 1998). Contextual factors influence the planning and therefore the learning. There are four general principles that reflect the effects of contextual factors that influence a change to learner-centered methods in the classroom (Craig L. Frisby in Lambert & McCombs 1998, p. 61-77).

1. *Life is unfair – you can't control from where you're from for example, your genes and so on.*
2. *The environment plays a vital part influencing learning.*
3. *Life circumstances are rarely static but are susceptible to change.*
4. *It changes educators to think psychologically rather than ideologically.*

The importance of children's learning has been little to do with whom the parents are, but in what they do. So growing up in an academic environment helps for studies in higher education.

Instilling or supporting a continuing motivation to learn may be the most important underlying purpose for schooling (Sarason 1995). American psychologists association (APA) appointed a special task force to surface at the principles for learner-centered education to help reform and redesign the school system in the 1990s. They established 14 and underlying them are the fact that learning is maximized when the students are intellectually challenged "in linking new information with existing knowledge in meaningful ways." (APA 1997). Intrinsic motivation through positive emotion, personal interest and control to promote learning despite differences between the learners must be supported, as well as their awareness of their capability for learning in the process (Lambert & McCombs 1998, p. 82). According to Lambert & McCombs: "Knowledge is constructed by the individual as a result of the interactions between the individual and the environment!" (e.g. Piaget 1969). So environments for learning where different types of interaction are nurtured are fundamental for the learning process.

An important step in the development of phenomenographic research was the extensive study on learning done by Marton, Dahlgren, Svensson and Säljö (1977). They describe a traditional approach to knowledge:

1. *Knowledge is a quantity, in other words earning more knowledge is knowing more "knowledge fragments".*

2. *Knowledge is reproducing, i.e. repeats what someone said or wrote.*

3. *Knowledge is of "either – or"-character*

They describe the Holistic view on knowledge: Figure out what's important, what is the content from the text and understand the mission in its all. No human approaches an assignment with an empty head. Learning leads to a change of our conceptions about the phenomenon throughout the world around us. What happens then to that conception over time? To what extent can you say it does not change by new knowledge? So all learning is due to circumstances and is heavily dependent upon the environment it is presented in, and with or to whom it is explored. Keeping a memory depends on the meaningfulness of the material. Remembering is a creative activity. This process leads to various qualitative differences in keeping the knowledge. Is there a difference to the treatment to the material to be learned that is the cause of the skills displayed?

Is it a good idea to let the students take an IQ-test before a course in Electronics? Are there IQ-tests that benefit "good learners", and different type of learners? Are there tests that show ability to deep learning? Generally there are fewer relations between study success and methods and habits, than between study results and attitudes and motivation. (ibid p. 66). Despite that mathematic ability and earned knowledge are interesting parameters to consider in the study of the conceptual development of the students.

A factor that affects the study result is a holistic direction of your studies, with a developed external processing. The opposite is learning atomistic which by the principle means you learn the text literally. Study activity can be measured with presence in education, the amount of consumed course literature, time for studying, when to study and how much (in relation to the exam), the quantity of repetition, particular circumstances (ibid p. 80). There is a clear pattern between worse study pattern and passed exams (ibid p. 83). Atomistic students develop a worse study pattern when the courses become more extensive and come later in the academic year.

Qualitative differences in understanding of content are the decisive differences in comprehension and knowledge. Another important difference is the contrast in mastering

concepts that are crucial for new knowledge (ibid p.84). The most important step to prevent students from learning shallow is to remove the factors that guide them not learn on depth (ibid p. 117, as well as Biggs & Tang 2007). Things promoting shallow learning are the character of the exams, lack of meaning and relevance to the education, and bursting curriculums. The most important rule for examination is always to adapt and vary it in harmony to what the education demands. It is an obvious risk that the education becomes a steeple chase where the tests are the hurdles and at the end of the race you're still at the same level as you were at the beginning. To create conditions for understanding is a difficult and time-consuming process. Clearly the volume in terms of concepts and principles must concentrate to become less to create the necessary conditions for deep learning. It is better to focus on the really hard core of the concepts that is the foundation and the logical context with the subject (helping to understand the wider base of it). There is of no good to try to put too much into education.

The prime task as a teacher is to become a catalyst when the students lack of questions and create conflicts in their incorrect arguments they built up (Marton et al 1977 p. 138). "The price for understanding that's paid for cutting down the content of the courses is apparent." Therefore, it becomes even more important to evaluate what really matters (contently) to teach in the courses. What is learned without a meaning is forgotten in a hurry.

A very important effect of education is that it influences the students understanding of knowledge and changes it, which changes the way they approach new information and education. (ibid p. 152)

"Scholarship reconsidered"

The headline is a quote from the title of a much attentive book by Ernest L. Boyer (1991). He looked at the service as a college and University professor as a whole where teaching was a natural component to describe the academic skills. The faculty teachers are also learners and simply transmitting information was not good teaching: You must transform and extend it as well. Thus, through reading, classroom discussions, components and questions posed by the students professors will evaluate and better their practice and "be pushed in creative new directions" (ibid p. 11): Inspired teaching keeps the scholarship alive. To accomplish a more united service Boyer suggested that academic knowledge for a scholar is acquired through

research, synthesis, practice and teaching. These four categories – the scholarships of discovery, integration, application and teaching are the intellectual functions that decide your skill as a professor. The four are therefore separate skills tied together; you must master them all. Jencks and Riesman (1968), according to Boyer, points out that teaching does not help in getting your salary, and bad teaching is not penalized in any formal way. Therefore there is no incentive to develop your skills as a teacher so professors at research universities are not encouraged or obligated to pay any attention to developing their teaching skills. There is a widely shared, thankfully now becoming more and more out of date, observation that professors lack of vision, their disdain for education and the reluctance of function as a teacher reflects on graduate schools pedagogic training negatively (Eble 1972). The resistance on being a teacher is perhaps mostly unintentional, but still the same-old lecture notes are used, although some more student active moments like projects could be spotted, mainly from the new teaching staff. Naturally there are inspiring professors in the classroom but that was probably the case 200 years and more ago as well. The problem lies not entirely on the (lack of) enthusiasm shown, but more the unwillingness and incompetence in developing as a teacher.

The most important factor for students' learning is the teacher' personality and interest in finding ways to support student's learning. There are numerous learning AND teaching style inventories, other than Kolb's LSI, and this text will not try to enumerate them, but one of the most influential is the Grasha-Riechmann teaching style inventory where the different teaching styles are (Grasha & Yangarber-Hicks 2000):

- *Expert – Possesses knowledge and expertise that students need. Strives to maintain status as an expert among students by displaying detailed knowledge and by challenging students to enhance their competence. Concerned with transmitting information and insuring that students are well prepared.*

- *Formal authority - Possesses status among students because of knowledge and role as a faculty member. Concerned with providing positive and negative feedback, establishing learning goals, expectations, and rules of conduct for students. Concerned with the correct, acceptable, and standard ways to do things and with providing students with the structure they need to learn.*

- *Personal model - Believes in "teaching by personal example" and establishes a prototype or how to think and behave. Oversees, guides, and directs by showing how to do things and encouraging students to observe and then to emulate the instructor's approach.*

- *Facilitator - Emphasizes he personal nature of teacher-student interactions. Guides and directs students by encouraging cooperative as well as independent learning activities. Good at questions, exploring options, suggesting alternatives, and encouraging students to make informed choices. Overall goal is to develop in students the capacity for independent action, initiative, and responsibility. Works with students on projects in a consultative fashion and tries to provide as much direction, support, and encouragement as possible.*

- *Delegator - Concerned with developing students' capacity to function in an autonomous fashion. Interested in having people become self- directed, self-initiating learners. Students work independently on projects or as part of autonomous teams. The teacher is available at the request of students as a consultant and resource person*

There is an online test (see http://longleaf.net/teachingstyle.html) for teachers to determine how much of the types you are from above. To be honest the grading of each category is silly since there can never be the meaning from one person to master all teaching styles. As reasoned in chapter 10 the "teacher" function is a combination of them above, but in front of the class and involved throughout the learning process to the students, the expert and facilitator styles are the desirable.

The PBL perspective

Looking back in the mirror of Dewey and the concept of Learning by doing, Dewey and Charles R. Richards early established that the project work in the educational process should assume a "natural whole" before dealing with parts (Knoll 1997). As analyzed in the paper of chapter 9: although there has been a change in the writing and composition of new textbooks the last decades, there is still an issue in presenting the whole before digging into details. The dominant ingredients of many Universities teaching are lectures based on axioms and basic theorems formulating a theory then to be used, for example, in

engineering purposes, i.e. a deductive curriculum. The lecture technique was a consequence from medieval education where books were not available to the students, and the lecture's main purpose was to read to the audience that took notes and copied the textbook. The 21st century, riding on more than 100 years of research in active learning and learning from experience and a social context, experience an explosion on visual and technical aids from the introduction of the electronic calculator to the Internet and the opportunity to have an asset to the whole world with a mouse click. Despite that, the development on the campus is still stuck in the Middle ages. There have, however, been efforts on more active learning and the PBL (Problem or Project Based Learning) is one of the methods developed in good spirit of Dewey, Whitman, Richards and upcoming social scientists of the 20th century as mentioned above. Regardless or not if you are a fan of the concept of different approaches to develop your teaching (and learning), it is hard to argue from the fact that education should be progressive. The development from the practice is a necessary part of the curriculum for the whole (!) learning community such as a University. According to Kolmos & Krogh (ed's 2002) the Meta perception of learning and the classroom are decisive for the meeting between the tutor and the students (Laursen 2002). The understanding for progression and learning taxonomy's are an element in the formation of the Meta perception (Brödslev Olsen 2002). The understandings of motivation and creativity in groups are other factors. (Andreasen 2002). The same concerns the understanding of collaboration in groups as an expression for both collective as individual processes (Keldorff 2002) PBL is built on experience pedagogic, learning by doing, and the foundation was written by John Dewey in 1910 as a method for solving everyday problems and scientific cognitive processes. He summarized the problem solving method as learning by doing. From the earlier presented kinds of understanding by Kemmis (2010) (understanding from experience and/or reflection on experience) Dewey makes the same distinction for his work (1925, 1934). Dewey described the progress of evaluation in general was made from an endless use of experiences but consciousness of the different cultures, and circumstance was needed to not being obstacles to the development of new knowledge: The observations had to be scientific. Further Dewey stated that the problem was not only to formulate hypothesis based on previous data, but to reformulate them based on gained data and how it was obtained and previous hypothesis. From a philosophic view he criticized that knowledge is gained solely from our senses and that true knowledge comes from passive contemplation of

objects. He argued for a historical belief in separation of knowledge and action, i.e. theory and practice. The ultimate resource of mankind in every field is intelligent action (Dewey 1929). William Robert McKenzie points out Dewey's strive for stressing the whole in the annotated early work of Dewey "The unity he sought was, in the broadest sense, the unity of thought and action" (Dewey 1972)

Project work and PBL origins from the same learning principles, and are quite similar, even though the models of teaching differ. In short you can say that the methods behind project work are developed at Roskilde and Aalborg University, while PBL as a concept is spread around the world, including Sweden. According to Kolmos (2002) the framework (as mentioned above) can be found from Negt/Kluge, Illeris, and Dewey on the Danish side, and Kolb, Schön, Lave, Vygotsky, Luhmann and Wenger from the rest of the world. However, it is not the theories it selves that is of interest, but the application to the method.

The McMaster project – establishing PBL as a concept

The PBL model was established as a concept in the 1960s from the McMaster University School of Medicine (Servant 2016). According to Servant, the first program started in 1969 for 20 students to become physicians. In Servant's unpublished thesis she digs deep into the history behind the start of McMaster's program, which was the origin in the concept of Problem based learning. The pedagogic from their new program was by no mean a new strategy for education, but it was the breakthrough for PBL. From Dewey, Piaget and Bruner (see above) you can clearly see the influences of working in projects and in situations that raise the students' intrinsic motivation, and there are examples from Harvard University as far back as 1870 and its law school on a case-based education similar to the cornerstones of PBL. In a historic view, it becomes apparent that PBL and case method in teaching was a reaction against lectures and the practices in law and medicine, for example. They were considered inefficient and disconnected from what really had to be learned. The Case Method at Harvard was introduced at both medical and business school but soon forgotten, and the old curricula and didactics were dominating again. One major difference between the case method and PBL at McMaster was that the cases at Harvard were studied before classes. Although it from Servant's extensive study on the origin of the McMaster founding program becomes apparent that references from educational philosophies such as Dewey and Harvard's case method were more incidental and secondary, the process towards the

teaching model is clearly a product from the founder's own experiences and research in medical education from the past. So to be frank you can just establish the fact that the program was developed in a good Deweian and Lewian, or Kolb for a more modern reference, way based upon prior knowledge and experience, not depending on specific models already established. The lack of theoretical foundation, as Servant suggests, is perhaps not that distant after all: All knowledge must be a product and process of previous knowledge and experiences. You become much influenced from some, and less or even ignore some (Most of your sources from previous experiences will be ignored, in fact). Since your aim for something new, it is important not to get stuck in the old. The McMaster program has had a huge impact of higher education across the globe. You might wonder why and a simple explanation is given by Geoffrey Norman: "Woodstock"! The summer of 1969 formed a new generation (The Woodstock generation) that revolutionized the World in so many ways: The breakthrough for civil rights as an obvious example. This is also the time when the Teacher starts to become something more than just an expert passing on information in higher education.

From McMaster's founding program some particular areas stood out that differed from other medical programmes at that time:

- *The integration of disciplines under the umbrella of a systems approach.*
- *The use of small groups as the unit of learning.*
- *The development of problems as the starting point of learning.*
- *The limited use of lectures.*
- *The quasi disappearance of assessment.*
- *The inclusion of a community outlook throughout the programme. (Servant 2016)*

This was the first program that succeeded in combining the learning of fundamental science and clinical components within the organ system, glued together through biomedical problems of authentic situations that the study groups were facing. The basic science and the clinical components were organized into a matrix form for each system. Although the system of matrixes actually worked it was not trouble-free. The amount of work setting up them was far from self-going. However, the tutorial teaching and problem based learning in self-directed smaller groups become what later formulated the concept of PBL. The small-group tutorial was described by Neufeld & Barrows (1974) as a laboratory of learning about

human interaction and a place where interpersonal skills can develop. The simple idea was that group dynamics make the sum of the individuals greater than a whole, based upon previous knowledge, experience and so on. The tutoring in small groups provided for a very communicative facilitation process between the students and the tutors. In the McMaster program seven labeled methods of education was mentioned:

1) *Guided instruction in large groups,*

2) *Developmental discussions in large or small groups,*

3) *Tutorials as mentioned above,*

4) *Field trips in small groups,*

5) *Self-learning,*

6) *Lecturing in large groups (Used for guest lecturers, inspiration and time saving organizational information), and*

7) *Recitations in small groups (Servant 2016).*

So the curriculum was far from decided just by method number 3). The distributed time between each method was to be decided during courses. The tutor had a crucial role for the assigned students since there were no formal examinations; it was the tutor who "assessed" the group members and decided on when they could enough. As lots of the planning even the exams seem rather ad hoc in how it was performed.

The sources of inspiration for the medical program at McMaster came from the Harvard case method, Western Reserve University, and the Oxbridge tutorial system. Nothing was copied, but the influences come from notes and interviews of the education committee. The Education committee (EC) started with "The Founding Fathers" where Harry Thode, John Evans and Bill Spaulding played an important part setting up core documents for the program (Servant 2016). From Evans the program objectives were divided into knowledge, abilities and attitudes. The philosophy was formulated as "the ability to identify and define health problems, and search for information to resolve or manage these problems", according to Servant. The term self-directed learner was stated, possibly connected with the Rogerian tradition of education theory from the 1950s. The suspicion is motivated because of the EC references to Roger's T-groups. The connection between self-directed learning and Dewey's theories on what motivates the pupils seems apparent. The two broad objectives to

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the program were formulated by Spaulding: "…help students to become effective solvers of biomedical problems" and "To foster attitudes[…] as responsible physicians and researchers" From there the lack of formal assessments is also discussed that the evaluation of the students would be considerably dependent on frequent evaluation from the tutors. An interesting fact is that the only two intellectual influences from philosophic educators are Abraham Flexner (1866-1959) and Jan Amos Komensky (1592-1670). Abraham Flexner has a key role in the reform of the medical education at the beginning of the 20th century, and was also a researcher at John Hopkins University (see John Dewey), but Komensky was a Czech pedagogue from the 17th century who wrote Great didactics. One of the key founding of Komensky was that he thought "teaching and learning should be pleasant, based upon the interest to the pupil and not coercion" (Servant p. 84). Although Dewey is never mentioned within the framework of the McMaster program, his appearance is quite obvious. Besides already mentioned ideas and philosophy from him, he urged for the teacher as a guide facilitating the students.

After the establishment of the medical program in McMaster, several parallel projects like that saw its day view of the globe. The characteristics are therefore somewhat difficult to summarize since the concept varied much between institutions (De Graaff & Kolmos 2003). Since PBL is developed mainly from lots of practices it is hard to theorize the concept; to summary the essence of its nature besides the obvious student-centered learning, learning by doing and learning from experience through facilitation. Kolmos (2002) formulated the following central theoretic learning principles of PBL:

- *Problem-oriented learning in which a problem situation provides the starting point and direction for the learning processes and serves to focus students' attention on the formulation of the problem rather than the answer or a solution to the problem. The problem situation does not have to be concrete or realistic, even though this is often the case. It could also be a theoretical problem formulation. What is most important is that the student asks questions and moreover, dares to raise questions. In addition, this allows the learning content to be related to the context, which again promotes students' motivation and comprehension, because the content is related to a broader perspective.*

- *Who formulates the context of the problem depends on the next principle; that of participant-directed learning, or as it is most commonly called in the Anglo-Saxon literature, 'self-directed learning'. In most cases, the students are expected to find their own problem formulations within a given subject framework. In other cases, the teacher formulates cases, which serve as the basis of the students' learning processes.*

- *Interdisciplinary learning is the third principle, which is closely related to problem-oriented and participant-directed processes as solutions to the problem formulation may span across traditional subject boundaries and methods.*

- *The Exemplar is the fourth principle associated with problem-based learning and is based on the premise that the educational benefit for the student should exemplify the objectives of the framework provided.*

- *Teamwork is the final principle included in the PBL model. It reflects the idea that most learning processes occur in groups and teams.*

From De Graaff & Kolmos (2003 & 2007) and from the text above the following description and interpretation is done:

Problems and cases are in focus for learning. The type of problem leads the learning process. The answer itself is not the most important, more the Evocation. The problem is mostly practical, but nothing prevents it from being theoretical. The problem shall be formulated to attract and inspire the student to seek understanding and solutions. This leads to a larger and better achievement. Goal setting is of major importance in the process.

Anyone can formulate the problem or project. The students can quite freely be responsible for setting the goals for the project. It is encouraged to seek problems and projects where the students can apply their previous knowledge and experiences, which could raise the motivation level further.

The activity is a central part of the learning. The student is stimulated to seek for knowledge on his own. Open-minded teachers are necessary not to get stuck in a rut from how problems "should" be solved. The student often becomes an expert in a small area. Therefore, it is important that he gets a wider perspective of the field to similar problems, and even how to apply his new-found knowledge in new areas. The learning is to take place in groups. That way, the ability to cooperate and handle group processes is developed. The

project work is scheduled in blocks of approximately six weeks. The students can choose for themselves what kind of project to work within.

The cases are a practical problem or at least something most likely. From the Aalborg model, a seven-step method is used attacking the problem:

1. *Understand the problem - Clarify and explain the concepts*
2. *Define the problem*
3. *Analyze the problem and come up with a possible path towards a solution*
4. *Seek answers and work with the problem*
5. *Formulate learning goals – What am I expected to learn?*
6. *Seek more information about the problem – is there more to learn?*
7. *Report and test the new information of the problem – gather information on how to solve the new questions that are found and report it.*

Study groups are established, and the different cases are discussed. They meet with the facilitator once or twice a week. The facilitator eases the learning process without giving away any answers. The way of communication is the facilitator's responsibility. The group must make sure that the assignments are solved in a satisfactory way. Often the exam is oral and individual.

"The learner-centered principles relate to five essential dimensions of meaningful learning that have been systematically investigated… … Those dimensions are:"

1. *The knowledge base – One's existing knowledge serves as the foundation of all future learning by guiding organization and representations, by serving as a basis of association with new information, and by coloring and filtering all new experiences.*
2. *Strategic processing or executive control – The ability to reflect on and regulate one's thoughts and behaviors is essential to learning and development.*
3. *Motivation and affect - Motivational or affective factors, such as intrinsic motivation, attributions for learning, and personal goals, along with the motivational characteristics of learning tasks, play a significant role in the learning process.*

4. *Development and individual differences – Learning, although a unique adventure for all, progresses through various common stages of development influenced by both inherited and experiential/environmental factors.*

5. *Situation and context– Learning is as much as a socially shared undertaking as it is an individually constructed enterprise. (Lambert & McCombs (1998 p. 20-43)*

The medical school in Maastricht in the Netherlands and the University of Aalborg, as a result of merging several institutions, was founded in the 1970's and both adapted the PBL model as the learning strategy. According to Kolmos (2002) the Maastricht model "work is performed in study groups, often with defined cases in short thematic blocks and with individual exams.", and for the Aalborg model "work is conducted in project groups in which the group members choose their problem formulation from within a given subject theme and subsequently take the final examination together by defending their shared project." Since the McMaster model did not specify how the works with the tutor in the small groups were to be conducted, this is a good example on two possible different directions from the same basic idea.

Chapter 3 - Inquiries made 2013 - A pilot study

You have to start somewhere so the teacher decided to take action on how to make the students more involved throughout the learning process and increase the discussions between him and the students as well as between the students themselves. The changes were:

- *Preliminary test of electrical and electronic skills from previous courses – It was a terrible result!*
- *Test of "IQ", number sequences – The result was slightly better than on the test above but not by any standards acceptable.*
- *Interactive lectures. They were voluntary but he knew who took which. – Around half of them took the lectures online.*
- *Analyse of exam – surprisingly they failed on two fairly simple Q, one that is the basic formula of the whole course and one that required them using the simplest of circuits to get the right level on output signal.*
- *Continuous evaluation during course about how they feel and think they progress. Like a diary.*
- *Evaluation when they got their exam back analysing their result from expectations.*

There were some conclusions to be made from the collected data but no lucid connection to his research questions. In the eager to present a result, the strategy was not clear enough and the collected data become indecisive and too much of a blur. Although it gave him further insight to the understanding of the learning process, and a new focus was born. The group process, which was the main focus of the initial study, showed some interesting and rather surprising results; the group of "leftovers" became the most successful, and the two groups that reported most hours working together also did OK on the exam, but besides from that, the number of students passing the exam was still as low as the years before so even though the students enjoyed the planning, the results were as disappointing as ever. Accepting the fact that fresh experiences nurture new questions and ideas, the necessities for clarity and more precise research questions were obvious. The main drive for his efforts was still the idea to make the students perform better so he needed to understand how to get the students to understand how much effort to put in, and to study more efficient. In his head he had seen groups of students study, almost running away from classes, despite they

were probably the ones needing the time more than anyone. Since the students obviously did not remember what to be learned from their previous courses', data about their foregoing results on the 1st year courses was collected, and the ability test of number sequences was kept as an introduction to the next year's course. The result from both inquiries was written down and was later complemented by the results from the exam. An interview was prepared for the students after the course, and everyone was invited to participate. As many as 42 out of 46 showed up, and the data was summarized and interpreted (Chapter 6 and 7). The investigation became the foundation of a teaching model that could be implemented and further analysed and evaluated (Chapter 8). The variables for his interest were now motivation and deep learning

Chapter 4 - The confinement of the thesis

There are so many interesting topics within the field of learning and teaching. Lecturing, Motivation and engagement, deep and surface learning, CDIO, PBL, ELT as parts of the concept of Active learning, conceptual and procedural learning, learning styles, both individual and in groups, computer-aided teaching, flipped classroom, and so on. So as a teacher and researcher into the field of education and learning you must narrow it down and decide what is important for you. Being a teacher for more than 25 years on different levels has made him aware on many approaches, and since he is the curious type, he has tested a large quantity of teaching methods and aids as well as various strategies of exams. To explore each and everyone one of these thoroughly would be a monumental task for the rest of his life. Therefore the main theme of the thesis is grounded in the latest findings and what caught his mind the last couple of years. As an experienced teacher lots of the knowledge in meeting your students is sitting in your backbone. His attention turns to what is the focus of this stage during the development process. Being a fan of Kolb's experiential learning theory each course is being evaluated from the changes made to improve the learning environments for the students. So to type his story the perspective will automatically be narrowed down to the latest issues of interest. He could quite simply write a book about all his experiences, but that would be a lame attempt to "cover it all", full of surface reflections and holes, and probably not very instructive to the reader. So the main contribution for him as a practicing teacher and educational researcher will be to summarize his experience and try to tell his story on how to create inspiring and engaging learning in the classroom. Therefore the focus will be on the narrative study and the learning taxonomy he adapted. The revision of the Bloom taxonomy by Anderson, Krathwohl and Bloom in the perspective of deep and surface learning will be considered. The firm belief in accepting a framework to promote deep learning is every practitioners strive.

Deep and surface learning in the concept of the revised Bloom taxonomy

Benjamin Bloom (1956) identified three domains of learning: the Cognitive (thinking - knowing, reasoning), Affective (feeling - emotions, attitudes) and Psychomotor (doing - physical skills, practice). The taxonomy has been used worldwide as a template for learning programs, and a major revision was made by Anderson et al (2001). It was a framework for classifying statements of what students shall learn from instruction, see figure 1.
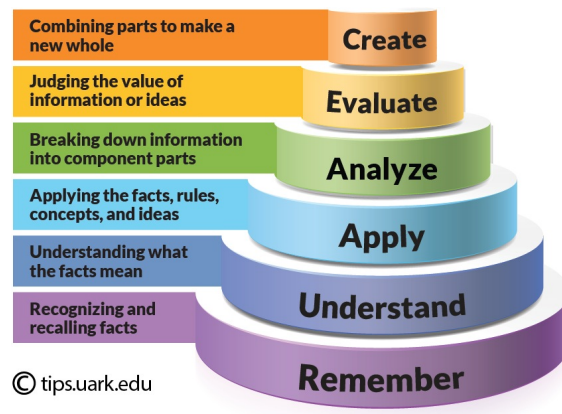
Figure 1 – with courtesy from Jessica Shabatura of the
University of Arkansas

Bloom believed his original taxonomy could serve as a (Kratwohl 2002):

- *common language about learning goals to facilitate communication across persons, subject matter, and grade levels;*

- *basis for determining for a particular course or curriculum the specific meaning of broad educational goals, such as those found in the currently prevalent national, state, and local standards;*

- *means for determining the congruence of educational objectives, activities, and assessments in a unit, course, or curriculum; and*

- *panorama of the range of educational possibilities against which the limited breadth and depth of any particular educational course or curriculum could be contrasted.*

The revised taxonomy added another dimension to the verbs, namely the knowledge dimension. It divides learning into four categories; facts, conceptual, procedural and meta cognitive. The cognitive process dimension was revised some. The figure 1 is not from Bloom and his research group, but an example of a popular interpretation of the different levels of learning, not telling the whole story. It is always dangerous with simplifications like the one in figure 1. It is good for memory, but the risk is that the picture replaces the actual content of the model it describes; It thus removes the core of the content to a shallow representation. In the revised taxonomy, the evaluation is to more precise place learning goals and outcome in the matrix to help the teacher to value the content of the curricula.

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The model is far from uncontroversial: Like all models attempting to describe our world and the human, it can never be decisive and to 100% accurate. Steve Wheeler (2012) highlights some of the issues with the taxonomy. One is the fact that all learning can be measured from putting it in the matrix of the two dimensions. In the digital age where learning is changing the discrete (!) boundaries of learning activities become blurred. Assessment methods are changing, and the classroom is not physical in a classic sense. Much of the learning can now be attended via the Internet. Campuses are no longer the necessary nurture for learning, and it is not too bold to foresee a major revise for their roles in higher education. Consider learners' ability to be creative, critical and independent and the knowledge more and more in a social context, the taxonomy cannot handle and measure intuition and creativity. Wheeler's prime concern is in the sequence of learning in the taxonomy: "…cognitive achievement cannot be represented as a single linear process." Theories like connectivism, heutagogy and paragogy are suggested on learning in the digital age of the Internet. So are they replacing behaviorism, cognitivism and constructivism or are they the emperor's new clothes, or what? Siemens (2014) mentions the three classic learning theories as products from where knowledge was not impacted through technology. In forty years we have gone from careers that lasted a lifetime, to where knowledge sometimes is measured in months. According to Siemens knowledge is growing exponentially and therefore fresh methods for deploying instruction are needed (Gonzalez 2004). Siemens (2014) principles of connectivism:

- *Learning and knowledge rests in diversity of opinions.*

- *Learning is a process of connecting specialized nodes or information sources.*

- *Learning may reside in non-human appliances.*

- *Capacity to know more is more critical than what is currently known*

- *Nurturing and maintaining connections is needed to facilitate continual learning.*

- *Ability to see connections between fields, ideas, and concepts is a core skill.*

- *Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities.*

- *Decision-making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision.*

Connectivism also addresses the challenges that many corporations face in knowledge management activities. Knowledge that resides in a database needs to be connected with the right people in the intended context in order to be classified as learning. Behaviorism, cognitivism, and constructivism do not attempt to address the challenges of organizational knowledge and transference.

Another networked learning theory has evolved and one of the definitions that have proven central within the networked learning community (Ryberg, Buus & Georgsen 2012) is from Goodyear, Banks, Hodgson and McConnell (2004, p.1):

> *learning in which information and communications technology (ICT) is used to promote connections: between one learner and other learners; between learners and tutors; between a learning community and its learning resources.*

There are some issues within the theory of connectivism as a new learning theory. It does not seem to be a strong awareness or references to the existing research in networked learning (Ryberg et al 2012). The development and debate are also in a forum of a blog and not in the academic research where the framework must undergo reviews from experts within the field. Ryberg argues there are some underlying differences in the notion of connectivism and networked learning such as the perceptive relations between the individual and the social, and their view of cognition of learning. An example from Aalborg University discusses methods to promote connections not only in the study groups of the traditional PBL, but to widen the perspective of learning through communication between groups, groups and communities at different stages of the program, and groups and communities outside the academia. It is clear though that the increase of social networks and web 2.0 influences attitude and performance and offers other learning environments in higher education.

So the revised taxonomy cannot be considered dead quite yet. Before exploring the revised taxonomy more in detail the connection between deep and surface learning and the taxonomy needs to be illustrated. Marton and Booth (1997) argue that pedagogy depends on meetings of awareness, meaning that the teacher takes the part of the learner and the learner's experience. Case closed: By being aware of the students' prior knowledge instruction can be performed towards the new learning objectives. The revised taxonomy helps us position the learning objectives in the proper context. One problem still to solve: How to figure out the positions for the objectives? For the more gifted students traditional lectures and textbooks are enough to provide them with the necessary knowledge, learning the concepts utilized to present the new knowledge. If all the students were really clever and motivated, teaching would be a feast where you as a lecturer simply just needed to be an expert available for questions and discussions. However, many of the students are not that smart, and surprisingly not that motivated either. Still they have the potential to reach the curriculum's learning objectives and function in the society as contributing workers. The teaching must promote the utmost effort to promote deep learning and create stimulating learning environments for as many students as possible. Ahl (2006) argues from the point that since lifelong learning is the solution to problems with increasing unemployment adult's motivation is of immediate interest. Theories, according to Ahl, concerning motivation and adult education suggests that removal of various dispositional, situational and structural impediments of motivation brings the adults to be naturally inspired to educate themselves. Ahl believes the right question shall be: "What motivates adults to take part in and complete courses in continued education and competence development?" Students can thus not be considered self-regulated learners just by attending higher education. In a report "The lecturer" (http://universitetslararen.se/) headlines "Research-intensive University compromises the quality of education" The annual report for 2014 shows that the University becomes more and more research-oriented. From 1997 the share of the total income has increased successively from 53% to 58% in 2014. The share of lecturers and researchers with a PhD has increased, so the number of professors (assistant and associate) has increased, and the assistant master has decreased accordingly.

Since he possesses a fair knowledge in the PBL and the Aalborg model his study promoting deep learning starts with a paper from the conference in Leicester in England in November 2000. Entwistle (2000) discusses for example influences on different approaches to studying and outcome of learning, and a conceptual overview of the teaching-learning process. After a rather extensive study within the field, it seems like a fair starting point since the work of Noel Entwistle emphasizes the earlier findings and studies deep learning from a sound perspective proposing new learning environments. A part at the conference concerns Knowledge transformation.

Concepts and procedures

There is not a consensus from research in handling the concepts of procedural and conceptual knowledge promoting deep learning. Budd et al (2005) argues that the de-emphasizing of procedural knowledge as less important has given dire consequences for student learning. According to Star (2005), others claim procedural knowledge should play a secondary, supporting role to conceptual knowledge in students' learning of mathematics (e.g. Pesek & Kirchner 2000). The definitions of Hiebert and Lefevre (1986); conceptual knowledge as knowledge rich in relationships and thought of as a network of knowledge, and procedural basically as rules of procedures for solving mathematic problems, misses the connection in between them and might be useful for young ages learning simple skills like multiplication tables of single digits and so on. So that concept is rather defined in terms of the quality of one's knowledge of concepts. Psychologically speaking Medin (1989) claims knowledge of concepts not necessarily rich in relationships. Since all knowledge is relative the concept of something has to start from the interpreter's prior knowledge; i.e. we cannot really consider the definition from Hiebert and Lefevre as complete. Furthermore, there is an issue with the definition of procedural knowledge as primarily sequential: It becomes superficial and mainly connected to remembering in the taxonomy. Some procedures are algorithms to remember, but some are heuristic meaning that there are different uses of the procedures in various contexts. A proper use of procedures can describe a whole system and therefore be a really powerful knowledge path. Knowledge of different concepts can be used procedurally to solve new problems; hence there is a skill to be able to use concepts in procedures in other problems than those in the textbooks (real-world problems). Just remember a procedure makes the knowledge very limited and therefore on the surface

(superficial). To be able to use concepts and procedures in problem solving you need to understand and apply them to create new knowledge. In doing that the learning gets deeper. The increasing availability and efficiency of computational tools imply that procedural knowledge can be achieved without deeper conceptual understanding (Engelbrecht, Bergsten & Kågesten 2012), and further conceptual and procedural knowledge are seldom present as distinct entities. According to Engelbrecht et al (ibid) research has shown this interdependence of procedural and conceptual knowledge to be highly complex. From Hiebert (1986) Silver (1986) considers that conceptual understanding is neither necessary nor sufficient for procedural knowledge. An individual's ability to use procedural knowledge is independent of conceptual thinking (Baker and Czarnocha 2002). Baroody, Feil and Johnson (2007) suggested a rather contradict view on conceptual knowledge. They defined it as "knowledge about facts and principles" (ibid p. 107), without requiring that the knowledge is richly connected. The nature of conceptual knowledge should provide for the overall perspective. Merriam-Webster's Collegiate dictionary defines the concept as "an abstract or generic idea generalized from particular instances" (2012). Assuming knowledge is required to be richly connected was a more impelled definition earlier, but more recently the richness of connections as a feature of conceptual knowledge that increases with expertise is considered (Rittle-Johnson & Schneider 2014). Wolfer (2000) defines it more as a combination of the heuristic procedural knowledge and concepts: procedural knowledge is to understand and apply the concepts learned in any problem-solving situations. Conceptual knowledge can be seen as procedures of concepts understood and applied!

Surif, Ibrahim and Mokhtar (2012) argue from comparing students' abilities to solve problems by algorithms with interview questions based on the involved concepts, that most students are weak in conceptual knowledge. This was noticed from the fact that many students solved problems successfully but in interviews, answering questions about the concepts showed significantly less understanding. Most students rely on algorithm problem-solving techniques (Cracolice, Deming & Ehlert 2008). It occurs that students mainly memorize the necessary formulas of the processes without learning and understand the concepts. The development of both the procedural and conceptual knowledge is a dynamic process growing in parallel (Baroody et al 2007). For example, Wu (1999) states that procedures have to be learnt first in order to develop conceptual understanding, and Brown,

Seidelmann and Zimmermann (2002) argue for teaching with problems that require an initial reasoning linked to their prior knowledge, i.e. conceptual understanding, first. Studies (Pesek & Kirshner 2000, and Chappell & Killpatrick 2003) show that students taught for procedural (instrumental) knowledge without further explanation, i.e. learning formulas, performed worse than students educated in conceptual (relational) knowledge on both procedural as conceptual tasks. So the conclusion is that pure procedural knowledge taught provides a more limited understanding both in procedural and conceptual understanding.

There are three clear levels of understanding: procedural in terms of following a remembered recipe for calculating an asked for variable or design. There is the heuristic procedural approach where the necessary steps are evaluated from your knowledge and experience following a (well) thought-out structure in calculating the needed unknown variables or systems. The conceptual knowledge gives an overview of understanding, but not necessarily the ability to complete the task. However, the conceptual level of understanding gives you the whole, and it is much easier to search for the necessary relations needed to determine the unknown variables of the system. Purely procedural methodology cannot lead anywhere but to a more or less surface process of learning and knowledge. The heuristic procedural approach helps you to consider the problem and step by step reach the solution. This makes the deeper learning possible. The conceptual learner has always an opportunity to be a deep learner, but that presupposes the ability to find out the necessary relations needed for the calculations of the system/problem.

Knowledge is relative: this means that every person has different experience when exposed to new knowledge. The higher you come in the education system the more complex the learning becomes; the presented knowledge consists of concepts and procedures. A concept can be derived from the top—down perspective: Concept can be simple facts, but also (complex) systems described by properties. It is important to realize that systems always are concepts. When you open the system you can approach it from different angles depending on the complexity. You can learn the system by understanding all the pieces from your experience, but also apply procedures to solve problems within and with the system. Procedures can be algorithms; you only need to remember them, and heuristic, meaning you are aware of and understand a number of concepts and perhaps other procedures as a building stone of the system, and then can apply these to solve problems within the system.

The system itself is applied in other systems or stands on its own. Surface learning implies remembering procedures without understanding the consisting concepts: deep learning involves the heuristic use of procedures based on an understanding of the different concepts. Heuristic use of procedures is the base of the concept. Using the taxonomy and considering difficulties to separate conceptual and procedural knowledge, since the more complex the problems become, the distinction between them are less important since the knowledge consists of a system and its content of procedures and concepts. Thinking knowledge as facts helps creating fresh knowledge based on what you already know (facts). Presenting the content as a system (Top) followed of describing the content of the system based on earlier facts and new concepts (facts and concepts) create new procedures (down), and thus establish new knowledge.

Lots of different views and surveys points in one direction in higher education: you cannot simply focus on one or the other in terms of concepts and procedures. They are firmly tied together and needs to be considered from the situation it will be applied, and treated in relation thereafter. The connection made in the survey of chapter 9 to the taxonomy suggests a mix of concepts and procedures depending of the context and what to understand and apply. Sometimes it is a concept, sometimes a procedure, and quite often a whole chain of them.

Motivation – promote student engagement through learning environments

George Lucas recalls, "My own experience in public schools was quite frustrating. I was often bored. Occasionally, I had a teacher who engaged me, who made me curious and motivated to learn. I wondered why school can't be interesting all of the time"[5]. We can probably recognize ourselves in the quote. As an instructor or a teacher, you can prevent pervasive disengagement by being proactive and create communities that promote participation, belongingness and engagement (Shernoff 2013). A significant number of young people become disconnected from school by disengagement (Smyth and Fasoli 2007). Kelly and Price (2014) found that engagement declines by about 10% from eight to tenth grade. In response to student disengagement teachers lower their expectations, causing a vicious interactive cycle. As many as a third is found being disengaged because school is not challenging (Shernoff 2013). Further from Shernoff the search for, and implementation of,

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[5] see, for example, http://www.edutopia.org/word-from-george-lucas-edutopias-role-in-education

the one best school system looked at the students as a group, and schools started to ignore what we know about how humans learn and are motivated. Einstein was also into the fact that students are to be considered as individuals: "Only a free individual can make a discovery. […] Can you imagine an organization of scientists making the discoveries of Charles Darwin?" (Einstein 2011), and "It is only to an individual that a soul is given." (Einstein 1954, p. 43).

Student engagement impacts academic performance and achievement positively (Fredricks, Blumenfeld & Paris 2004). Shernoff (2013 p. 10) claims that the importance of engagement can therefore be reduced to its relationships to achievement, and continues: "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 & Morrison 2003). Shernoff defines engagement as (2013 p.12): "The heightened, simultaneous experience of concentration, interest and enjoyment in the task of hand." The definition is based completely in the experiences of students, i.e. a learning experience. Creating "flow experiences" (Csikszentmihalyi 1990) is an optimal state of cognitive and emotional engagement. Students score higher on measures of self-esteem, responsibility, competence and social relations when they are interested and involved in skill building and productive pursuits (Steinberg, Brown & Dornbusch 1996). So consider the optimal engagement as an important outcome in the evaluation of educational environments the science of human potentialities can be of maximum benefit to the individual (student) (Shernoff 2013 p. 13).

The aim for higher education (as well as all development) is to promote happiness and well-being (Noddings 2003). So for a teacher at an engineering program you need to:

1. *Set the course in a context of other courses as well as the working life,*
2. *Show its practical use and utility,*
3. *Address the course well towards the learning outcomes presented, and*
4. *Promote happiness and well-being.*

For the practicing instructor, in order to create optimal learning environments in the classroom, the questions how do the students get engaged, who and what are the students engaged to, needs to be answered.

From Deci (1996) we can come at the conclusion that the autonomy of the learner is the absolute key to motivation. So nurturing the will pushes the learner forward intrinsically. As an instructor you train the will by motivating and engage your students. Desired schooling behavior can be somewhat difficult to define but disengagement shows by failing to pay attention, complete homework and attend classes regularly (Shernoff 2013 p. 47). Schools are in a unique position to facilitate students' engagement to learn. Therefore, activities that support creativity and self-efficacy as well as showing the students what is necessary to master the content is very important. From the definitions on engagement by Newmann et al, Furrer and Skinner (ibid): Engagement is an interaction in an environment. So the planning needs to consider where the learning takes place as well. Environmental conditions fostering identity, development, self-esteem, initiative or a sense of purpose often mediate greater engagement with the students (ibid p. 51). In goal theory there are two primary beliefs about ability: Mastery (attain knowledge and understanding, success is attributed to effort) and performance (a desire to appear competent (or appearing not incompetent)) goals (ibid). Particular for the mastery involvement is the greater depth of information processing, bettering the ability for learning itself; Learning makes the individuals feeling happy, calm and excited rather than sad, tense and tired (Linnenbrink and Pintrich 2003). However, students see academic learning as a means at an end rather than the value in itself, i.e. a performance goal. Since motivation and engagement is among the most important tacitly learned outcomes, understanding the learner is very important and the first step to know how the educational environments affect the learning processes. To change old ruts the question "Where is the learning?" can replace "What is learning?" (Shernoff 2013 p. 128). Shernoff is concerned that in the process of change institutions rely on specific models in books presented by popular practitioners. Adapting a model often becomes just a pale (or diffuse) shadow of its origin. Focus on the existing environment, the learners at hand, and setting specific goals for both the institution itself as well as the learner must be the drive of the process for change and development. The instructor needs to identify the fundamentals of engaging instruction, including cooperative learning techniques and one to one-attention. This should lead to a deeper relation to learning environments in general, even towards the community and the industry. The classroom itself is not merely physical but a mental stage for the student when engaged. Lutz, Guthrie and Davies (2006), Lamborn, Newmann and Wehlage (1992) and Shernoff (2003) list challenging

and complex activities as primary factors to students' interest and engagement in the classroom. Talking equals teaching in higher education supports the increase of disengagement. Of course a great deal of what is learned can be accomplished through speech and demonstration but most of what is heard in a talk are not learned (Shernoff 2013). Weimer (2002) states that the teacher can achieve learning goals by having the students explore and experiment with content and relate to their own experiences. This is consistent with learner-centred and constructivist approaches. The perception of importance is by far the strongest predictor of engagement, and also the most robust of perceived learning and attention (Shernoff 2013 p. 140). This underscores the importance of teachers placing activities and course content in a larger context so that the students can appreciate the value of what they are asked to learn and do. They must clearly understand the importance to the activity for themselves and their future goals. It is important to see the difference between establish your own goals as a teacher in the learning, and the proper context for the students.

Other perceptions of classroom instruction highly related to engagement: Contributing with valuable ideas, being active, and that the activity is useful in the learning process, also the perception of investing effort. In creating this learning environment the students need to feel that they are contributors to the learning community.

Chapter 5 – Methodology

Introduction

Mixed methods with a clear social constructive theoretical background, means qualitative as well as quantitative inquiries in a context with people from different backgrounds and qualifications for higher education (Creswell 2009). Studying at the University and evaluation of the outcome is heavily dependent on the milieu the study is taking place within. Therefore, as seen in the intro, it is dangerous to draw any general conclusions on teaching, learning and the learning environments created. However any evaluated practice made has some value and can be a base for further investigations and applications where some conclusions can be put in the basket for analysis of the collected data or a practice. Combined with experience and successful (and failure) stories a knowledge base is built up, which probably provides for more stimulating and nurtured institutions for learning. The most important parameters become willingness for change and the use of reflective practice for continuous improvements. The culture in this study supposes merely the practice of your own and no institutional decision for change of the curriculum of the teaching. So the basis to the study depends on the narrative view of a single lecturer in an attempt to optimize his service, although a discussion on cultural effects is included in the summing up.

A philosophical reflection on objective and subjective knowledge

In an episode of the sitcom The Big Bang theory, Sheldon Cooper, a theoretical physicist, argues with his deeply religious and literary faithful in the Bible mother, about the Evolution theory: She replies: "Everyone is entitled to an opinion, Sheldon." –"The Evolution theory is not an opinion, it's a fact!" –"And that is your opinion!" she comes right back at him. Very few would argue with the fact on Darwin's evolution theory, but still people, for different reasons, choose not to believe in it. The search for describing the world objective, i.e. finding the truth, is something that has been the goal for many scientists in the history of mankind. However, there is no certainty in objective knowledge, only tentative hypothesis. A highly probable hypothesis is not an objective statement, but a psychological. Scientific hypothesis need to be interpreted psychologically, and be presented in an environment where it is valid and makes sense. Science may be seen as a further development of common sense, just as a scientific fact can be found as a systematic extension of situations from real life, but science is about finding the truth. So science needs to go beyond the world of mere appearances

and what the evolution has endowed us with. Science is possible due to that fact that it can be presented in text and critically assessed. The thesis becomes an object that can be dismissed. Subjective beliefs, like in the case of the example with Sheldon and his mother, can therefore not be dismissed: You cannot persuade someone who does not want to change their opinion. So objective knowledge is true as far as we know until this point whether you choose to believe it or not, and subjective knowledge becomes objective for the ones that choose to believe in them, but in a general (objective) sense they come somewhere in between objective and subjective.

Knowledge can be graded in different ways. From a certain "truth" in science such as acceleration as the derivative of velocity, to patterns for factory workers under specific conditions try to improve efficiency in production, such as Kurt Lewin's famous study on the factory in Harwood. This kind of knowledge is of course more circumstantial than the relationship between acceleration and velocity. As long as there are no humans involved, observations and surveys on the nature could reveal truths. In a historical retrospective most science is not the actual truth, but the scientists have become much better to describe in what environment the laws work within. So this is as close to the truth we can come. Laws and relationships that can be observed and show the same conclusions, regardless of who conducts them, is objective knowledge and is valid as long as no one proofs otherwise. All other knowledge is more or less subjective. Knowledge about the human mind and how we think can be more or less objective, but will always include some subjectivity. From observations we know that most people learn better when they participate actively in the learning process besides just listening, so this is almost a truth, i.e. objective knowledge on learning. The effects on learning in PBL, to consider another example, is dependent on many different factors and it is disputable whether it is better than the traditional approach to teaching and learning in higher education. Under some circumstances the PBL method is a success, and in others it fails. So the positive effect is dependent on lots of variables and therefore the knowledge of PBL learning's efficiency is more subjective than the previous statement. Studying humans can thus not entirely tell the truth, but show more or less valid patterns among them under different circumstances. Studying a very large group of students taking an exam in algebra in the first semester and compare their result to different background data can show more or less probability to predict certain students' results.

However, it is not possible from this knowledge to predict and be accurate about the result of a specific student just by knowing the obtained relevant background data. Therefore the knowledge is subjective and can be useful in determining learning environments for specific groups or similar. As Dewey wrote we draw conclusions from our and others experiences. The narrative research works the same: From our and others experiences we learn from stories of more or less subjective knowledge. This is the narrative format of research when objective knowledge does not exist.

Asplund (1970) discusses different aspects on sociology and its validity as science. In one example he refers to an investigation on suicide written by Emile Durkheim (Le suicide). Durkheim's book is full of statistical data and tables and the first so called multivariate analysis of statistical data of a social behavior. Durkheim's goal was to prove causes and relations that led to suicide. From an empirical sociological modern view the approach is almost ridiculous as a contribution to the field. According to Asplund Durkheim was a representative of the "mysterious intelligibility" that was desirable among researchers before the qualitative view was accepted. He tried to find a truth about suicide simply. In a retro perspective his work could be considered as pure science fiction, but, as Asplund claims, this calls for an aspect with less view on knowledge: Inarguable there was and is a lot to learn from his book on suicide, and we learned much although his conclusions today seems almost ridiculous. It is all about see his story in the proper context and try to vision from that view. So Durkheim's description on suicide can be seen from the aspect he did, and despite its many questionable data contained a lot to be learned.

Scientists often strive to systematize Intelligibility and present it as laws or invariances. A survey collects the data and analyzes them with the methods of measurement. When it comes to physical laws, these can in some cases be examined objectively and contexts discovered and presented to apply more or less generally. Newton's laws apply in a macro perspective, in many situations, but with the theory of relativity and the knowledge of the microcosm and speeds up to the speed of light, Newton's laws are inadequate to explain the relationship between the forces. In social science phenomenon are also investigated, but here with a social ingredient: Anything perceived by individuals and groups is always dependent on its social context. Therefore, it becomes a social phenomenon and an expression of different interpretations, and shall as well be. Some absolute and general

truths can never be described. Nietzsche warns about using contradictory concepts as "pure reason," "absolute spirituality", "knowledge itself". These expressions require a thought about an eye that cannot be imagined, whose gaze may not have a definite direction, the eye's active and interpretive powers must be missing, although the vision is a vision only when it sees something. To Nietzsche there is only a perspectival seeing, only one perspective insight. (Nietzsche 1996(1887)). Asplund chooses the term "aspect"[6] instead of Nietzsche's "perspective".

Ludwig von Bertalanffy, one of the originators of the General Systems Theory in Biology, points out that, for example, the laws of thermodynamics can be applied to closed systems, but not necessarily in open systems, such as living beings. According to Asplund he affirms a linguistic as well as a biological relativity, without the sake of rejecting the concept of truth. There must be a correspondence between reality and how we experience it, and between reality and "categories" and "laws". There are evolutionary reasons for the concept of truth's sustainability, but it may be many, even any number. That all phenomena constantly end up in a relative condition makes the number of truths virtually unlimited.

Asplund argues further in his interpretation of Winch[7] that social science cannot be "empirical" or "objective" in the same way and sense as the natural sciences. The crucial difference is that social science is about meaningful behavior, which is meaningful only if it is governed by rules. The rules, in turn, require a social context. Another of Winch central concept is that a person's social relationships to their surroundings are showered by her perceptions of reality. By that means social science is a kind of conceptual analysis in which the meaning of all possible social context should be the basis of the ideas or concepts that people have of reality. Ferdinand Tönnies (1887, see for example Tönnies, F. (2012)). sorts out the sociological significance of the "Gemeinschaft" and "Gesellschaft ", where the first indicates the private and intimate of each person, while the other is the public life, i.e. the world and how it is perceived and interpreted. It is common in social science that society is proposed to be understood as two parts, but (of course) there are divergent views. Aubert (Vilhelm, norwegian 1922-1988) *fate-random selection* is such (See also Parsons five pattern variables) (Asplund).

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[6] from Ludwig Wittgenstein, Austrian philosopher, 1889-1951
[7] "The idea of social science," Peter Winch, British, 1926-1997

To further clarify the difference between natural science and social science Winch discusses Weber's[8] method to determine the context and rules. Weber uses the concept of "Verstehen" in the sense of an impending interpretation of a particular behavior may seem as evident as any, but will never be anything more than a plausible hypothesis. The hypothesis must then be verified. "Verstehen" must be supplemented by statistical surveys. Winch questions Weber's position that "Verstehen" is somewhat incomplete. Provided that a proposed interpretation proves incorrect through a survey, which is not the evidence of the erroneous interpretation that determines the interpretation's sustainability. What is needed then is a better interpretation. Thus, the fact that an interpretation is consistent with the statistical data is a testament to its durability. To understand, says Winch, is the same as making the point or meaning of what is being done or said. This then becomes eminently distant from the world described by statistics and causal laws. The difference between a scientific and a social phenomenon can also be seen as the science explains mechanisms and organisms, while society attempts to explain phenomena as mechanisms and organisms, falling simply because society is not an organism or mechanism. Society is thus likened to something other than just the community and will therefore always best be explained by the well (or not so well) selected analogies.

In science scientists try to express theories as universal in some sense. History shows that even science is related to human perception of phenomena. Toulmin[9], according to Asplund, is using the concepts of "phenomenon" and "ideals of natural order" for science to be able to describe the world. If we call the dynamics, we can start with Aristotle's ideal of the natural order. A body motion can be seen as a horse pulling a cart. Thus there is an external force (horse) holding the body in motion, and a resistance against movement in the form of friction, road roughness, etc. The body speed thus corresponds to the ratio between the external force and the resistance to movement. Continuous motion is the result of the influence and resistance. This theory is still applicable by Stokes' law, according to which the body falling speed in liquid is directly proportional to body weight and inversely proportional to the fluid viscosity. But as a general theory of the dynamics it will not do. Aristotle thus failed to realize that a falling body in air would accelerate. Important in this context is that

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[8] Maximilian Weber, German sociologist (amongst other expertise), 1864-1920
[9] Stephen E. Toulmin, British philosopher, 1922-2009.

Aristotle then saw the rest as a natural ideal and the movement as a problem that needed to be explained. The movement was thus a phenomenon. Galilei experienced a different ideal: that of the body in motion does not stop its movement when external forces cease to influence it. Galilei mahouts there with his ship that circulated around the earth endlessly. The continuous movement was thus the natural ideal. The phenomenon consisted in changes in body movement. So what needed to be explained were thus deviations from a given state, whether the object was at rest or in continuous motion. What Galilei failed to realize was that if the ship moves smoothly and without influence from external forces, it would disappear into space. Newton thus appeared the natural ideal as an object in uniform and rectilinear motion. The phenomenon was that the object was left on earth and gravitational theory was discovered. In this context Kepler followed the tradition and presented the laws on elliptical orbits of the planets with gravity as a natural ideal, although this was before Newton. Just now in the days (November 2016) NASA presented an accepted article in the Journal of Propulsion and Power 0 0:0, 1-12[10] that is in direct opposition to Newton's third law (action and reaction force are equal with opposite direction) so, even though it is not fully proved, it is yet another example on how even the laws of physics change over time and new natural ideals are necessary. Science is therefore best seen from different ideals of the natural order, not what is "right" or "wrong".

The point in understanding knowledge of the world is therefore the perspective, intelligibility or aspect of comprehension, not the knowledge itself: Understanding the ideal of natural order in each context. Some knowledge is easier to accept in a general sense, but consider how bridges are built: Although the dynamics of strength from loads are well known and tested, the demands for construction strength are several times higher than necessary according to existing (and well documented) knowledge. There are so many variables not considered so to avoid crucial mistakes bridges are constructed for many times higher load than subjected for.

Rorty (2001) starting point suggests that the language is a set of arbitrary sounds represented by letters, with a highly uncertain relation to an "objective" world. Pragmatism manifests "Words and worlds are different things". In the prolongation pragmatism dismisses the critical tradition with the view "Prejudices are all we have.", so we can just as

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[10] http://arc.aiaa.org/doi/10.2514/1.B36120 retrieved 2016-11-30

well use them and focus on ethical issues about consequences rather than on questions of "truths" or "representation". Instead, we should consider science and day to day problem solving as a game of linguistics where the question not is "What are the facts?", but "What am I allowed to say?".

If there was a natural order that was valid, discovering the truth would be like shopping at a supermarket where explanations were to be found like groceries on a shelf. Of course objective knowledge would be preferable, but history has proven objective truth is not that easy to find. Borge's bantered and fictive essay Celestial Emporium of Benevolent Knowledge, or the Chinese emperor animal classification, highlights the absurdness in the thought of a natural order and inspired for example Michel Foucault to write his Order of things that describes and discusses the origins of human sciences.

So is there a better method to obtain more valid answers in qualitative research? Is a narrative view scientific "enough"? Well, besides instinct the oldest source of knowledge is from storytelling and it is hard to argue against that stories are the utmost important source of knowledge yet to found. Based on the philosophical reasoning above every experience and finding including humans, is relative a surrounding and context that are unique, and therefore not repeatable. But understanding the natural ideal at that time and place, helps us to understand conclusions on and of human behavior, and increases the understanding of the world of humans. Czarniawska (2004) stresses that "there are no general theories – only theories with general claims".

Research design and the philosophical world views

To intertwine research inquiry with the political agenda the advocacy and participatory world view developed a more qualitative approach than the constructivist view (Creswell 2009). The clear focus on changing lives than "just" studying processes on humans makes the research more including for the participants to control and influence the inquiry. The feminist perspective is one that comes to mind; without knowing what is desired the contribution to the study must be limited to what other finds interesting, not a strive for equality between sexes. The pragmatic world view is a mixed methods approach not committed to any system of philosophy and reality (See Dewey above). Inquiries can collect data from both quantitative as qualitative data, whatever suits the best purpose. Thus great

freedom is permitted to the researcher to form their own strategy and approach. There is no absolute true to be discovered. Truth works here and now and can accordingly never be copied in any other situation. We learn from experience, and the pragmatic researcher uses data and previous discoveries at equal importance. Any method, world view, assumption and collected data can be used and analyzed.

According to Creswell, Quantitative data can be collected from experiments where a specific outcome is expected. The experiment shall be repeatable under the same conditions. "Survey research provides a numeric description of trends, attitudes and opinions of a population by studying a sample of that population" (ibid). Variables to be measured are determined and inquiries are designed to give data accordingly.

Further from Creswell Qualitative inquiry approaches have become more and more popular from the 1990s and on-forward. Ethnographic design studies an intact cultural group in their natural setting over a longer period of time and collects mainly data from observations and interviews. Grounded theory searches for generalizations of an abstract theory as a process between groups (and the differences) grounded in the views of the participants. Case studies attempting to explore more in detail an abstract process that is bounded in time and activity. Phenomenological research identifies the essence of human experience of a phenomenon described by participants. Narrative research is telling stories from your or others experiences.

Mixing quantitative and qualitative strategies can be described in an endless stream of variations. According to Creswell, three general strategies for the mixed methods approach can be illustrated: The sequential, the concurrent and the transformative. The sequential seeks to expand a (smaller) study with another method. The concurrent mixes quantitative and qualitative data obtained from the research problem at the same time. Then all data is interpreted integrated with each other. In the transformative the researcher uses a theoretical lens over the whole perspective of the inquiry. The lens is the box that encloses the research problem in all. Selecting research methods as the basis to the research problem and what to be investigated becomes the next choice. After deciding what variables that are valid it is a question on what shall be determined with quantitative methods and/or qualitative. An example is shown on the table (ibid p. 15):

Table 4 - Quantitative, mixed and qualitative methods

Quantitative methods →	Mixed methods ←	Qualitative methods
Predetermined	Both predetermined and emerging methods	Emerging methods
Instrument based questions	Both open- and closed-ended questions	Open-ended questions
Performance data, attitude data	Multiple forms of data drawing on all possibilities	Interview data, observation data, and audio-visual data
Statistical analysis	Statistical and text analysis	Text and image analysis
Statistical interpretation	Across databases interpretation	Themes, patterns interpretation

Grounded theory from the advocacy and pragmatic view, mixing both quantitative methods (results from tests) with qualitative was used in the inquiries of the thesis. The qualitative data was collected basically from three different approaches: partly the experienced communication in the classroom as well as the communication between the teacher and the students about life and career in general. Meetings were sat up as weekly gatherings where the students were encouraged to discuss the content and whatever crossed their mind during the learning process. Since there was an opportunity to interact continuously with students taking the same course the initial planning from the pilot study gave a necessary input towards the research questions and the goal for the project's development, a framework was created what to examine and how. This was not detailed since the class itself had a big influence on the outcome of the cognitive processes examined so the data collecting became a product of the initial planning as well as the outcome of the processes and interaction among the students. The belief in Kolb's learning cycle kept the ball rolling and was used during the whole process.

Kolb's learning styles
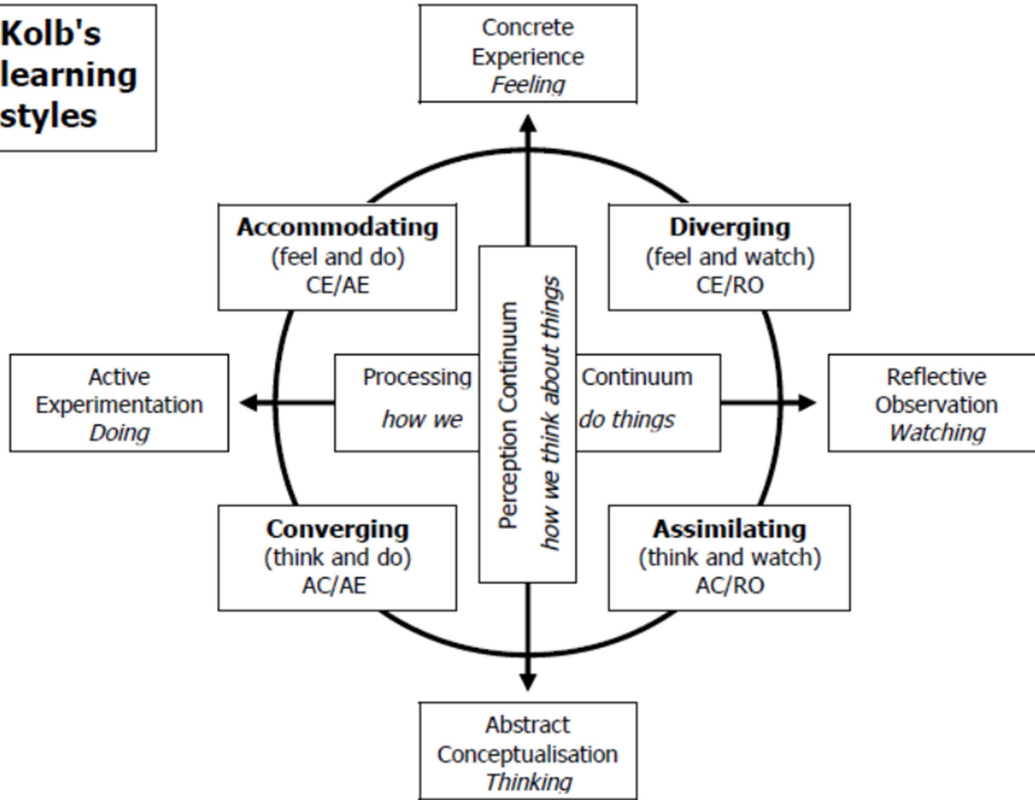
Concrete Experience
Feeling

Accommodating
(feel and do)
CE/AE

Diverging
(feel and watch)
CE/RO

Active Experimentation
Doing

Processing
how we

Perception Continuum
how we think about things

Continuum
do things

Reflective Observation
Watching

Converging
(think and do)
AC/AE

Assimilating
(think and watch)
AC/RO

Abstract Conceptualisation
Thinking

© concept david kolb, adaptation and design alan chapman 2005, based on Kolb's learning styles, 1984

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Figure 1 - Printed with courtesy of Alan Chapman

The whole course was for obvious reasons one lap in the cycle, but also parts of the course became a spinning cycle. One was the repetition of the working model each week. Each Monday began with a reflection on last week and conclusions to be drawn to better not only the planning of each weekly model, but also to affect the students' own approach in the cognitive development, to become more active and responsible for their own learning and their communication with the tutor (facilitator), the group work and how to get the most out of the learning environments presented. So it comes to no surprise that all classes from three years were quite different, not only because of the yearly revision of the teaching model, in performance and experiences and how the planning was executed. The main difference to the research process was the insight of the somewhat naive urge for finding a superior teaching and learning model soon disappeared and developed into a more qualitative study on intrinsic and extrinsic motivation, and its relation to working more efficiently towards the learning goals. To be quite honest the outcome of the exams did not improve significantly, but it is the fact that more students got better grades, and there were more students who were pleased with the new way of learning although they did not pass the exam. Data cannot be secured that suggests an improved outcome from the course, but more students have completed the course via rest exams than before. This can of course depends upon all sorts of things other than a different teaching and learning model.

Action research

Work and studies that happen in the context of action need to involve and engage the participants. It requires a partnership where the outcome and research questions are shaped in collaboration and influenced by the studied objects. The research becomes cycles of action and reflection, and the researcher has to be reflexive on how the impact of his presence intervenes. In the performed data collection tests and questionnaires have been used as evaluation tools, complemented with interviews to be able to follow up answers on the prepared questions. The questions have been open as well as multiple choices. To reduce the influence of the teacher as an interrogator much time and care have been spent on preparing the questions asked. They have not changed even if it turned out that they did not give the exact right focus.

A narrative view

Doing research in engineering education can be frustrating since the number of papers in the field is enormous. Just googling on "lecturing and engineering" on papers and books published from 2015 and forward (2016-05-18) gives you about 5000 "hits". "Deep learning and engineering" give even more: about 7500. To consider taking into account all the research and finding in these areas are a monumental task in itself, if not impossible. So how to find sources and actual contributions usable for your own research? Even this is an example on the narrative view of research: You must use your instinct and filter not to drown in an endless pile of papers and books. What are the filters then? There are of course books and papers worldwide recognised as "classics" from highly renowned researchers and icons like Dewey, Vygotsky, Piaget, Kolb and Entwistle: well-known and well worth their credits. However, so much has been done in the field of learning engineering just the last couple of years, and you have to consider the latest findings, no matter how hard it is to keep track and select from the huge pile of contributions. This means that his contribution in the selected fields can only show a glance of the publications and findings, and the motivation for the narrative view becomes even more motivated since this is his story, and this is what he came up with from his resources and limitations.

Narrative research means a biographic perspective on stories: it is actually a story about your life. It is not about quantifying information in numbers or other terms. It is a qualitative method in an inductive procedure in collecting and computing data. The inputs of his practice are thousands of interviews, mostly informal and not accurately written down but where the essence has caught his attention, results from exams given, endless lectures, lessons, laboratory exercises, project works, and relaxed coffee breaks with students, to mention some. Mishler (1997) defined narrative as an accounted description aimed to illustrate a contiguous sequence of events. This is according to Berteaux (1983) a life history in the meaning that his story is complemented with other sources and data. Clandinin and Connelly (2000) set a distinction between story and narrative calling the phenomenon story, and the inquiry narrative. Narrative research is defined by Lieblich Tuval-Maschiach and Zilber (1998 p. 2) as "…any study that uses or analyzes narrative materials. The data can be collected as a story (a life story provided during an interview or literary work) or in a different manner (field notes of an anthropologist who writes up his or her observations as a

narrative or in personal letters)." This is well in harmony with the social-constructive perspective that was his first intention in his inquiries. So from the winged expression Learning by doing by Dewey and a social constructive perspective, narrative inquiry sums it up as the methodology to use. To conceptualize the field of narrative inquiry you need to study experience. As Connelly and Clandinin (2000) his view of experience is rooted in John Dewey's (1938, see, for example, Dewey 1986) pragmatic philosophy. Dewey claimed that a theory is needed for experience. All genuine education comes from experience, but this does not mean that all experience is to consider as educational. Experience must grow for further experiences. Dewey argued for the misconceptions of "the traditional school", depending on automatic drills, and the "new progressive school" not considering the connection to meaningful development and pupils "…came to associate the learning process with ennui and boredom. (ibid p. 27)" and what they learned was so far from life outside school that the power and drive to learn were almost eliminated (He later describes the meaning of purpose in education, regardless of what scholar system you work within). Dewey's two criteria of experience are interaction and continuity. People are always in relation and social context (interaction), and experience has two aspects: the immediate that are either agreeable or not, and its influences upon later experiences; hence continuity. Clandinin and Rosiek (2006 p.42) argued that "a pragmatic ontology of experience [is] a well-suited theoretical framework for narrative inquiries, [because] narrative inquiry is an approach to research that enacts many if not all of a Deweyan theory of inquiry". They developed further a metaphor of a three-dimensional narrative inquiry space drawn on Dewey's criteria of interaction and continuity and his notion of situation. These are: The personal and social, past, present and the future, and place. So any inquiry has three temporal dimensions and addresses temporal matters (Clandinin & Connelly 2000 p. 50). Working within a narrative inquiry makes you therefore complicit in the studied space. As participants of our own studies, it is important to realize that you enter other stories, with other narratives. Accordingly, analysis of other environments could or should be done. On the other hand, numerous possibilities open for the interpretation of data and composing of texts.

In the context of the Deweyan philosophy on learning and teaching and narrative inquiry the step to Jerome Bruner is not far. Bruner's (1960) ideas about cognitive development are based on the importance of partly the ambient design in the interplay between milieu and

the individual, partly the individual's own conditions and the motive for learning. The motives are three: The competence motive – show yourself and others that you can accomplish something, the reciprocity motive – strive toward a goal with others, and the curiosity motive – the desire to know and learn something new. He saw the children as active problem solvers ready to take on difficult subjects. Four important elements are

- *The importance of structure in the curricula: Knowing how things relate to each other are of importance instead of just teach facts and techniques. If the earlier learning shall ease the later, the whole picture with the relations what you already learned and what to learn must appear as clear as possible.*

- *Maturity to learn: Even young children can learn complicated material, assuming the instructions are disposed in a pedagogic and adapted way. It is important to work in a spiral principle constantly come back to the basic concepts. Repetition is necessary.*

- *Intuitive and analytic thinking: The teacher gives example on how teachers can nurture intuition.*

- *The teacher's motive: The intrinsic motives are ideal, in contrast to extrinsic such as grades. The motives for learning can never be passive; you must as far as possible to arouse interest for the pupil what there is to be learned.*

For further reading of narrative inquiry and storytelling Thomas King's The Truth About Stories: A Native Narrative (2003) and Huber, J., Caine, V., Huber, M., & Steeves, P. (2013). Narrative inquiry as pedagogy in education the extraordinary potential of living, telling, retelling, and reliving stories of experience. *Review of Research in Education*, *37*(1), 212-242. are recommended.

Experiences from a change to student active teaching in a deductive environment: actions and reactions

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Abstract

Courses in engineering often require deep learning ability such as explanations argued using evidence and individual conceptions of the topic (Entwistle, 2000). Since the frequency of completed exam has gone down at Higher Educations engineering institutions in Sweden (report UF 20 SM 1303, Swedish higher education authority) the level of the general student's ability seems to be decreasing. Also the number of students has gone up by 20 % from 2001 to 2010 in the first year (registered students on the faculty of engineering at Uppsala University) which calls for other teaching methods and ways to generate conceptual knowledge and learning.

The methodology of the study is a narrative inquiry part of a mixed-methods research in a social constructive perspective on achievements and reactions of students who becomes responsible for their own learning in a teaching model based on student active methods like flipped classroom and problem based learning (PBL) with a clear conceptual focus. Since the main goal of the inquiry was to get their responses without leading questions and put it into perspective of my 25 years of experience in teaching adults on different levels, I have decided that the best way to analyse the data is within a narrative approach. In interviews students from a bachelor and a master program in electrical engineering indicate how they experience the differences, benefits and flaws, and how it affected their learning, awareness of their ability to learn, i.e. self-efficacy, motivation to learn more and how it developed during the course. The study reveals the factors that make the student passive instead of following and taking part of the working plan and also contains an analysis on what drives students to make the decisions on their attendance and effort.

Keywords: Motivation, conceptual learning, facilitation in terms of supervision, PBL, flipped classroom.

Background

Experiential learning theory (ELT; Kolb 1984) aims to help the learner "to learn how to learn". With ambitions to continuously improve following the recursive cycle of experiencing, reflecting, thinking and acting, the learning power can increase. The development of you as a teacher comes from the simple fact that you see yourself as a learner (Kolb & Kolb 2009).

From a teaching career of 25 years, 15 of them at university level, I have experienced a change in attitude where the students has gone from accepting a structure and the teaching, to where the students require and demands more teaching and showing less prior knowledge which has led to a big change in the structure for the courses. The passing rate has gone down and the students feel less motivated to get a grip on their own learning and realize that it is up to them if they will succeed or not. In my experience it looks like the general opinion has turned from them knowing they have to learn by themselves to a belief that the teachers shall do the learning for them. Maybe this is just a grumpy old man's declining ability to create learning opportunities for the students. I have also experienced the transition from independent to more "demanding and needy" students that are formed in "old school teaching", a deductive approach of lectures, lessons in terms of a tutor solving textbook problems, and laboratory experiments to clarify the theory described in the textbooks. The constant request from the students has been for more teaching. In this model that is what they are familiar with. This leads to reactions and negative energy which moves the objective from learning the content to formal issues about "too difficult courses", "impossible exams". As a result, instead of studying hard students start to search for possibilities to pass the exam in other ways, for example by requesting alternative examination and/or demanding another examiner. For me personally that entailed a transition from being a very popular lecturer to a suspected one and I experienced the frustration of feeling insufficient in my tutoring and guiding of the students towards the required knowledge. Therefor I have tried the last three or four years to move the focus from the teaching process to learning in the classroom. The key aspect has been to raise the conceptual level of the teaching in the classroom and focus on *discussing* problems and its´ solving in contrast to just presenting the theory behind it and *showing them* how to solve problems. "Learning takes place through the active behaviour of the student: it is what he

does that he learns, not what the teacher does" (Biggs and Tang 2011). In 2013 a pilot study was made in a course in electronics, introducing preparatory lectures and a focus on problem solving during class. In my pilot study I came across lots of new concepts and strategies to encourage the students to prepare for my teaching in class. I introduced micro teaching, flipped classroom, PBL and other methods to make the learning process more effective and the students more active. The main focus was to make the time with the students more efficient. The students' responses were in general positive, but the results on the exams were not significantly better. Therefore I was motivated to find out more about student active teaching and how to implement it. From my experience I reflected over the results, the students' evaluations and many hours of discussions in the lecture hall as well as the laboratory with the students and came up with a teaching model that would even more increase the activity in class. One particular field they experienced difficult was the step from discussing real world problems to be able to solve them themselves. Therefor I introduced another step of problem solving confirming the theory instead of jumping directly to the real world problems. Besides analyzing their exams and conceptual development I interviewed them to get feedback on how they experienced the teaching model and their own development during course. The results of this study are reported below.

Introduction

The study took place at a course in electronics the second year on two engineering programs in electronics at Uppsala University, a bachelor and a master. After a first year where 80% (37/46) of the students' passes 50+ out of 60 credits, many of them (69 % on the first exam) fails and finds the course so much more difficult to complete. The course consists of four parts; one is analogue electronics coupled to a number of assignments (=second part), the third is digital electronics in project form and the last is a project they decide on their own what to do related to the course content. It is especially the first part that causes the problems. The third and fourth part of the course is project based and it has been quite clear that the passing rate is much higher on that part, mainly because they work so much harder in projects together.

I am the lecturer of the course and have been that since the course started in 2010. The course started with 46 students that had the necessary entrance qualifications. The students

were divided into six groups of maximum eight in each and were encouraged to work in this group during the course, which lasted the whole semester. The later part was dominated by two major projects. The first part was mostly theoretical and the second parts assignments came from the content of the first. The assignments were individual but they were allowed to work on them together.

Table 1: The content of the course.

Theorethical part (5+5 hp)		Project part (5+5 hp)	
Analogue electronics	Assignments	Digital electronics	Their own project
OP-amplifiers Feedback Filter design and analysis Semiconductors (mainly transistors)		Design of a sequential circuit based on a given problem.	

A number of laboratory experiments were given on an optional basis. The planning of the theoretical part was rigid on a weekly basis with clear goals each week and contained the following:

- Web lecture and test of the fundamentals
- Conceptual lecture focusing on problem solving
- Lesson directly after the lecture where they were encouraged to work on simpler problems leading them towards basic understanding and applications of the topic.
- The above was then repeated the next day completing the week's theme.
- Time for them to work on their own under facilitation of the teacher. They were encouraged to work in the selected groups. This part included eight scheduled hours in class.
- A follow up ended the week where they either could take part of an optional lab or take a seminar with the teacher discussing what came up during this week's work.

The theoretical (i.e. the first half) part ended with a smaller project before a written exam where they built a rather complex device and implemented it on a pcb (printed circuit board). In the third part it started with a crash course of the fundamentals to give them some basic knowledge of the field, followed by a large project. After the crash course all

scheduled time was for the project under facilitation. They were to design a control system for a small elevator that was handed to them. Otherwise the instruction was quite open for them to decide the futures their solution should cover. The problems that arose were to be solved with facilitation from the teacher. The approach was inspired on the PBL at Aalborg University in their engineering programs (Kolmos, Fink, Krogh 2006).

This study examines how students act and react when they are exposed to teaching separated from the normal structure (see "old school teaching" above) and what I as a teacher can do to make them perform at their best.

Research questions

How do students adapt and react to an inductive teaching model and how does it affect their motivation and experienced conceptual learning?

Theory and definitions

Flipped classroom - Jonathan Bergmann and Aaron Sams recorded lectures and posted them online as a service to absent students. They noticed to their surprise that also present students used the lectures as rehearsal and came up with the idea to use the time in the classroom more efficiently. The time in class could now be used to work with problems and communicate with the students individually (Tucker 2012).

Blooms taxonomy – A categorization of the levels of reasoning skills in the classroom. They are knowledge, comprehension, application, analysis, synthesis and evaluation in the order he proposed (Bloom 1956).

Self-efficacy - A person's estimate of their own ability to perform a task.

Methodology

Narrative inquiry

This is a narrative study of actions and reactions from the students based on 45 individual interviews. Narrative inquiry is a way of understanding experience (Clandinin & Connelly 2000, p. 20). They developed a narrative view of experience from Dewey's two criteria of experience, interaction and continuity. The first criterion, interaction, implies that people are

individuals and has to be seen in a social context (p. 2). Continuity: Everything we experience develops into new experiences from our previous. So from Dewey's theories of learning by doing and experience there is a strong connection on a narrative approach to research. The experiential learning is inspired by the work of Dewey, Lewin and Piaget (Kolb 2014). All three of them are similar using experience and concepts to reflect and act upon to develop the concept. In the chapter of The process of the experiential learning he summarizes the process by defining learning as: "… the process whereby knowledge is created through the transformation of experience." So by filtering my students' experiences through my own knowledge I suggest further development in the process of creating student active learning and teaching in the mostly deductive environment. Well in harmony with the experiential learning cycle (p. 51).

The interview process

The planning included an icebreaker (Creswell 2009 p. 183): "How did you experience the course and its content?" followed by a number of more specific questions. The purpose was to hold the first question open to find out what first came to their mind and me influencing them as little as possible. They should quite freely put their mark to create an opinion. When they had respond to the icebreaker I focused on the comparison between the theoretical and the project part and asked them to compare them and put them into perspective of their previous courses. The common first answer "Really good course" is not accounted for in this paper since I wanted them to develop their thoughts more and explain what made it so great. The Icebreaker showed very clear what came to their mind. The results in this paper are interpreted from the interviews and all conclusions and future developments are solely based on what came up through the interviews.

Results

Four different topics stood out from the interviews, namely flipped classroom, the advantages of working in projects, the benefits and flaws from having all the teaching on a voluntary basis and the need for structure. The results are organized in order of the most significant responses and the headlines of the subsections derive from the concerned topics. I've included some theoretical background in some of them to clarify the thoughts behind each part of the learning environments that were mentioned and analysed.

Flipped classroom

To create an analysing and creative environment in my teaching I try to stimulate the students to move through the six stages of Blooms taxonomy. In my planning I lifted out the knowledge and the comprehensive level to reach the application level in the lecture hall. To make sure they understood I prepared a couple of questions on basic applications that was handed out at the end of the lecture. They were then invited to work with these problems during facilitation sessions. All this was done the first day of the week (and repeated the second). If they got past this they could more easily work with more complex applications and analyse as well as synthesize their new found knowledge during the week's facilitation hours in class. There is little doubt in students learn more if they come prepared. Fulton (2012) listed among other advantages using flipped classroom that classroom time can be used more efficiently, and teachers can see that the students' achievement, interest and engagement is raised.

More than 50% (24) identified the preparing lectures as an example of the really good thing with the course. They felt they could really benefit from the fact of being prepared and understand the conceptual strategy on the live lectures. Out of 47 registered students on Scalable learning (See http://test.scalable-learning.com/#/ for more information) at least 35 prepared by watching the web lecture and the reason was mainly the fact that the effort required no more than 15 minutes and no thinking what so ever how to prepare. It wasn't necessary to register to see the films since they are available on Youtube so there were more than 40 views/film before each lecture. The submitted tests however decreased in popularity since they first of all felt too hard, and second didn't come with a correct answer when they responded wrong. This was a future I wasn't aware of but there were explanations on the wrong alternatives why they weren't right. An additional asset was the use of the web lectures as rehearsal before the exam. Many of them claimed to have returned to them repeatedly.

Conclusions: In order to keep the preparation short and simple three or four very basic questions is enough to give them feedback that they can understand. Is it possible then to use the flipped classroom technique with tests of conceptual learning? Yes, and you should use it as a closing of the week's theme. The advantages are several: First of all the students get direct feedback of the week's work put in and if they learned what's been taught. Second

it gives you the opportunity to be even more clear on what you as a teacher think is the most important to know, and third, it gives you a good base for a quick summary of this week's work and an opportunity to close the bag on the first lecture of next week considering the result of the conceptual test.

Future development: More videos not just on the basics but also on specific more complex parts where a short web based lecture is applicable. It is not necessary to invent the wheel again since there are a lot of instruction videos on Youtube, online teaching sites for free, and even apps to your phone (for example: Everycircuit) which you can refer to and use as preparation and study material.

1.1 The structure

In 1790 Johann Gottlieb Fichte started lecturing without a prewritten manuscript. The knowledge was created on the podium instead of being tied to a textbook or another text. This is the breaking point between the Middle Ages authoritarian text reading to where the lecturer himself creates the knowledge.

Morton (2009, p. 59) suggests that the lecturer shall:

- Share their passion for the subject by explaining their passion for the field
- Linking to actual events and illustrate it with real examples
- Show the connection to the students prior knowledge
- Use rhetorical questions to make the student alert and follow
- Use the web to show the contents actual relevance

To create knowledge and deep learning you have to complement the above with one or two clear goals on what to understand and learn, and the ability to directly apply the gained knowledge in an upcoming lesson where the students work with problems on the application level (Bloom 1956). A clear goal unspoken for the students was to create an environment where they are stimulated not only to take notes but also to be enough aware of the lectured content so questions come up spontaneously.

Creating an inductive environment helps the students to gain a more comprehensive knowledge and develop learning on a much deeper level than the purely deductive approach (Prince & Felder 2006).

The main goal for this teaching is preparing the students for their own work. Ralph Tyler (1949) wrote: "Learning takes place through the active behaviour of the student: it is what

he does that he learns, not what the teacher does." Sounds easier than it is: The teachers (only) goal is therefor to put the students to work with problems that get them ready for the exam, or at least make them aware on what to learn. Their own studying took place as two four hour sessions, me facilitating the students when working together in the groups.

In the facilitation part they meet with the tutor twice a week. Their way of communication is the tutor's responsibility to make sure that the problems are solved satisfactory. They must put themselves into the students problem solving context and just not correct there errors (Lampert, 2001). Therefor the questioning to correct a misconception among the students is critical; a method is the reflective toss (van Zee and Minstrell 1997) in order to engage the student in the process of evaluating their proposal and refine the thinking towards a previously known model.

The structure of the first theoretical part was mentioned by half of them (23) as a significant improvement of the teaching and pedagogy. They knew from day to day what to expect and that was highly esteemed. They appreciated the teaching forming a clear thread covering the basics, the conceptual view, learning the concepts, and the facilitation process solving problems repeated each week. 18 of them, 14 expressed as the group work and 4 their own work, lifted the facilitation lessons with the clear conceptual focus in problem solving as most contributing to their learning. 11 of them relished the follow up lessons on the live lecture learning the concepts of the new area covered. One of the students rose from being 'average' to a 'top grader' and motivated the improvement with great interest and the structure. Still many of them failed to get a grasp of the content enough to pass the exam and issues like motivation (personal) problems (3), the lack of deadlines of the assignments (7), and no one pushing them to get going (4) were stated. An example of the mixed reactions was the two students who expressed the lectures as being "fuzzy".

Conclusions: Since almost half of them experienced difficulties working in the noisy environment during facilitation lessons an idea is to help them facilitate themselves by preparing more videos (see above) and a clear guide on how to use the internet and the many sites and programs available for analysing electronic circuits, in an attempt to make the groups an automatic cell working on its own but still with a facilitator around the corner. In order to make the working load manageable for the teacher their own studying in facilitation class should encourage them to process their problem solving skills in the

groupings and meet the facilitator on specific times. A more rigid structure at the start of the course is helpful to several who fail to get going from the start. One solution may be: Make them hand in one or two assignments in the first two-three weeks, offer a test after three weeks, or use the flipped classroom to give them tests on a weekly basis that becomes the foundation of the summing up starting each week as a closure on last week's theme. This is a golden mean between taking responsibility of your own learning and progress, and the need for structure proven by the statements above.

1.2 Time spent by students

Establishing their effort in working hours in the first half there was more than 50 % that estimated their working hours/week to less than 40, and as many as 35 % under 30. Most of the top performers (see below: Benefits and flaws…) saw the first part as eight hours working day, 5 days a week, but there were all kind of working hours among the ones that failed although less work guaranteed not passing the exam of course. In the project phase however they all were surprised how much time they had put in, many of them claimed "all the time awake". Less than five claimed no change and blamed illness or work beside their studies the reason not working as hard as the others.

The projects were highly appreciated, especially following a rather tough theoretical part. Here they really felt that what was previously taught was applied to real world problems. There was a significant increase in the working hours where only five of them still claimed to be working less than 40 hour, compared to more than half of them on the first part. That was even clearer in the passing rate that was as low as 14/45 (31%) on the first part and 38/45 (84%) on the second.

Conclusions: One way to motivate them to work harder is to give the group a responsibility towards all the participants. This could be done by letting them hand in a critical analysis of the week's work and what they did and did not learn and how they experienced the effort put in. That gives you as a teacher a good foundation for the summing up of the week's theme and an opportunity to stress what they experienced as hard to learn or work with. A conceptual test on individual level complements the feedback from the group. This can easily be done in Scalable learning.

Benefits and flaws from having almost all the teaching voluntary

Teaching at the university is mostly on a voluntary basis with compulsory assignments and laboratory experiments, sometimes put together in reports. I consider it to be one of the beautiful things with tertiary education that it is a smorgasbord for the students where they are supposed to create their own planning from all the information and education given, and the excellence in knowledge from the lecturers and researchers available. It is only the knowledge examined that counts, whether there is from written exams, oral presentations and/or completed projects. Therefor it was very important for me to do all the teaching and learning facilities available on a voluntary basis where the motivation and the urge for knowledge driving them to participate or not. The teacher is not going to be the attendance secretary, but the inspirator for the students to seek knowledge.

Looking at the performance in terms of grades almost all of them with a 4 or a 5 really liked the concept that all scheduled teaching and learning were voluntary and the fact that it was up to them to organize their studying. It was also obvious that many of them who failed the first part were quite aware of the responsibility on their own and that all the information and opportunities were there, but their laziness failed them. The need for deadlines and clear goals in terms of assignments and the teacher forcing them towards exam was apparent. One of them stated: "Voluntariness is evil". In the projects parts the grouping influenced them to work harder as seen in figures on the outcome of the test.

The students' ability to learn and their performance and effort put in are summarized in their self-efficacy. During the phase of creating an inductive model of teaching it has become clear to me that the curriculum has to consider what state of mind the students are in. It is easy not to take that into consideration since the responsibility of their studying is all on the students. However to allow for that there are students not 100 % motivated and prepared for the course given and let that influence the curriculum can turn the pendulum around and help the students not only to set the necessary goals on their achievement, but also to, from without their situation in real life, be realistic and for that reason find motivation to overcome issues that bothers them in terms of performance and effort. An individual with high self-efficacy works harder and longer than one with low self-efficacy (Wood Bandura 1989)

During the interviews it became clear that there were four types of students in terms of performance and effort. I have chosen to call them the leaders, the followers, they who got lost and failed to catch up, and the lazy ones who couldn't sort it out. Of course most of the best performers were to be found in the leaders group, but not all of them. The followers didn't feel that they contributed with ideas and were the ones driving the group; one of them described his part as "I contribute by being nice", but accepted the role and functioned well as it seem (from their point of view). One of them who took a clear leading role failed the 1st exam even in his 2nd attempt. Still he sent me a letter and thanked me for a brilliant course. Also one of the lazy ones who didn't study at all on his own passed both exams with good grades. Elsewhere the top performers were to be found in the leaders group and the followers managed to get by, some of them via the rest exam on the 1st part. Not one of them who failed to sort it out, 9 there is, passed the course. In the third group 7/12 managed to finally pass via the rest exam.

Conclusions: The categorisation is set to make it easier to determine what is to be done in helping them towards exam. Therefor you can set goals and plan for each of them to reach a reasonable goal and adapt your teaching with their character in mind. The difference here is that it is fairly easy to show what's necessary to reach specific grades, but seldom has the suggested curriculum considered what state of mind the students are in.

The 1st part saw a very high participation on the web lectures as well as the live lectures and the following conceptual lessons. Although many claims to have been studying in the facilitation lessons no more then 40-50% was present in the classrooms that were scheduled for the group work. They argue that the volume was too high and preferred to sit elsewhere. The concluding seminar and voluntary labs at the end of the week didn't work as planned. The seminars didn't become the forum for discussing the weeks work and therefor they ceased to exist and the focus on Fridays was in the laboratories. My conclusion is that the seminars is pointless since they have so much time with a teacher anyway so to partly get them going better from the start, and partly be more effective, assignments including laboratory experiments to be done at the end of each week combined with the already mentioned online test of the week's knowledge should be tested as improvement of the teaching model.

The awareness of knowing the whole

The course included a very well prepared study visit at a large company that evaluates their own electronics, and a guest lecturer from an advanced sound improving company corresponding well to a parallel course in signal processing. Together with the projects and opportunity to realize their own ideas many (25-30 %) of them expressed in different ways how the course helped them understand the role of the engineer and what's expected from them in the real life.

When asked to evaluate their own learning from without the learning processes six of them described themselves as "mathematicians", and more surprisingly five of them expressed they experienced trouble with maths! Many of them made the connection to some courses in the 1st year and four of them meant that the token has fell down. More than a third (17) expressed their understanding of electronics in context and finally they understood what they were supposed to learn in the 1st year. This was in particular shown that a lot of them started their own projects. They were definitely more aware and asked questions on a level I seldom get from more than one or two per year. That was encouraging and what really surprised me was the willingness to put in so many extra hours creating circuits "off topic", just to discover more. One specific project became constructing a functioning radio circuit which came out of the fact that we had discussed stability in terms of feedback, and oscillators using feedback to create an unstable circuit. There were three groups that worked really hard to solve this problem, almost like a contest, on which one succeeded first in sending and receiving music and talk in the FM band. Some of them (7) started their own projects, and two groups even "over-worked" one of the projects just for the fun of it. Other electronic problems on a fundamental level, for example what is really happening in the transistor when Ohms law ceases to apply, how come the feedback of an operational amplifier can vary from being stable to create an oscillator when the two inputs seem to be the same, were discussed, questions that rarely occurred during the years. This was by no mean restricted to the top performers or even the followers.

One of the students said "The most important role for a teacher is to engage and pull strings rather than being a reference book in a subject.", and continued: "This together with the fact that you know all of us by name and sit down and discuss whatever matters us, makes the communication on a whole different level then before (=previous courses)." To stimulate the

communication during lecturing to reflect on questions that are raised is there for appreciated but some reactions came also that thought the lectures became "fuzzy" and made the lecture notes a little hard to use and see a clear thread in them. So here a delicate question rises on what to pick up and what to neglect, in order not to inhibit the students to state their reflections on the content and create a conceptual environment during teaching in the lecture hall, on the expense of stringency and follow a prearranged script.

Summary

The development of the model is appreciated by the students. Both the structured theory part and the project based. To get the lazy students that failed starting right away there should be some assignments to hand in the first weeks. This could be combined with the suggested laboratory experiments mentioned above. Some well guided projects towards a very specific goal works well in larger groups (6-8/group), but in the project phase where the students are more responsible for the goals set and even what to construct there is a risk that students feel more like assistants to the more driven student and therefor, to secure a creative environment for everyone, the groups shouldn't contain more than 3-4 at the most to prevent that some of the group members fall between two stools and becomes passive during the creative process. The more open projects could also include regular meetings with the tutor to secure that they thought the process through before starting the construction work. This is by no mean a necessary requirement but more as another learning environment to consider in the process.

The teacher (tutor) has an important role to communicate with the groups what to be expected from their work. The dialogue shall help the group to set goals and a plan to reach them. The group is held responsible for their members and that they fulfil their goals; this has to be clear from the very first day.

Since the students experience a very high motivation in the project based part it is important for the facilitator to be the oil that makes the smooth engine run even more effective by encourage them avoiding hick-ups like malfunction equipment, difficulties finding time in the laboratories, a good system for them to order and find the necessary components, and, most important of all, be encouraging and supportive in their efforts and considerations.

To create the awareness there is so important to point out for the students that a huge part of the learning process is to find out how you, YOURSELF, can learn the most. How shall I plan my studying, what computer aids are available, which projects are suitable for me to dig in to? If you combine theory with a suitable project they design you can not only make them solve a more conceptual problem, you also most likely inspire them to get a grip on their understanding and awareness of what to learn. Not just to move further, but also how to gain the necessary confidence in the field making they maybe not reach the feeling of master the area, but a way to reach a level of understanding and a feeling of knowing where to find the knowledge. This must be a serious teacher's main goal in the planning of a course. Give them the necessary knowledge presented of course, but also how to get there, how to get the necessary conceptual understanding, and how to move on and be automatic in your future progress.

Further conclusions regarding the course development and more generalized suggestions about improving the weekly planning will be processed in another paper.

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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 2nd 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).
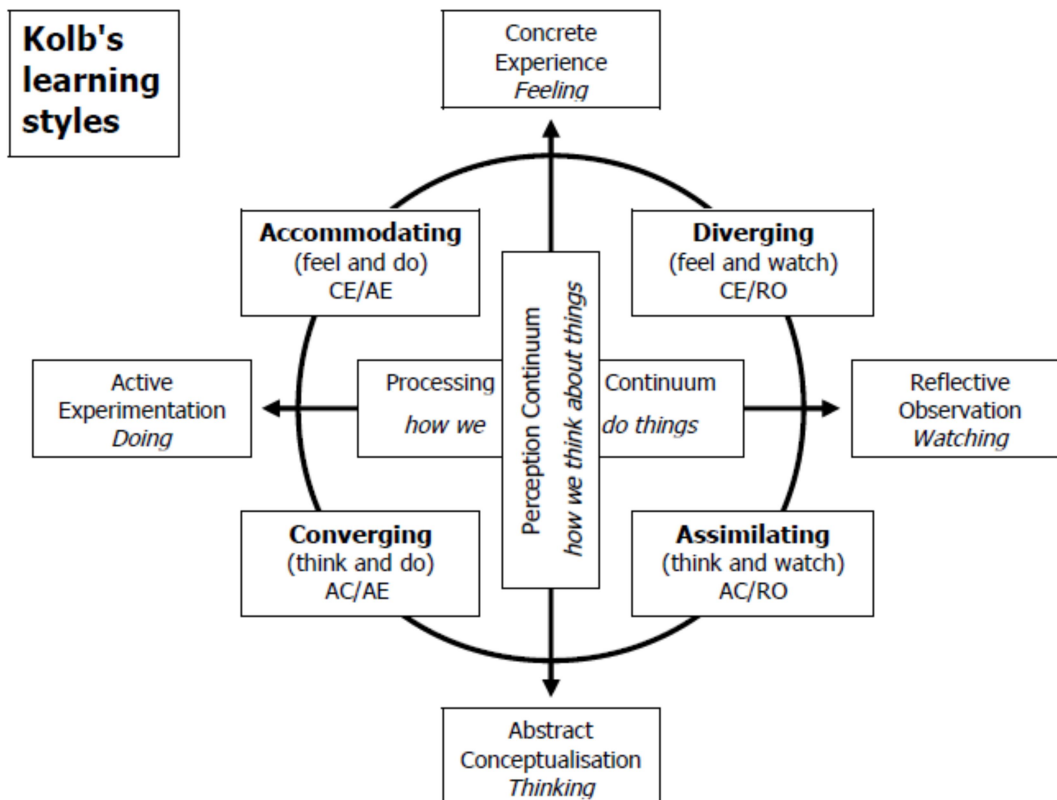
© concept david kolb, adaptation and design alan chapman 2005, based on Kolb's learning styles, 1984

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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.4.782a298813a88dd0dad 800012056.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.

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".

Result ability test
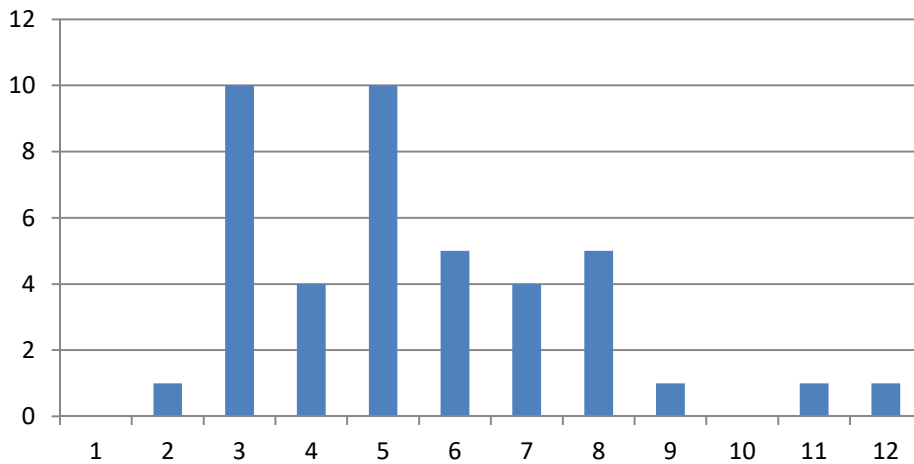
As can be seen only 13 managed to get more than 50 %, i.e. 7+ correct answers. I was quite astonished that as many as 10 only got three correct answers. During the first part, the more theoretical and abstract, they had a written exam and were offered to write a voluntary conceptual test where their 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 not to 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.

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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TEACHING AND LEARNING CONSIDERATIONS FOR A RESEARCH-INTENSIVE UNIVERSITY IMPLEMENTING ACTIVE LEARNING

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ABSTRACT

This paper suggests a teaching model and considerations implementing more student active methods in the learning process at a research-intensive university where teaching is mostly done in a traditional way.

During a three year period, efforts and methods to implement student active learning and find ways to motivate the students to work hard and focus on the conceptual understanding of the topic has been tested and evaluated. Despite using flipped classroom technique and many satisfied students, many students are still not performing at a satisfactory level. The more gifted students perform better but still the students who struggle cannot find enough motivation to pass. This article discusses a model used and its benefits and flows. A proposition for a teaching model is suggested that better suits the students and builds a better foundation for them to reach deep learning. The model suggests how to make the students not only active, but also enhance motivation and engagement to complete courses that normally have a low pass frequency. The paper compares different aspects on compulsory and voluntary teaching, seminars, laboratory work, facilitated lessons and assignments and how you as a teacher can organise your work on a weekly or module basis and create inspiring learning environments. The study was performed at Uppsala University in Sweden on a master and a bachelor programme in electrical engineering. Different active learning techniques are investigated and a model is presented that enhance motivation and focuses more on the conceptual knowledge in the instruction.

KEYWORDS

Student active learning, knowledge, teaching model, voluntariness

INTRODUCTION

During my career from 25 years of teaching I have always been interested in what goes through my students´ mind. However at the University I found myself caught by the traditions and became quite happy in just presenting interesting material, leaving all the responsibility for interpretation of my intentions and demands to the student. In 2010, to my big surprise, I received my first bad course evaluation and therefore decided that I needed to consider making some changes to my style of teaching. The

students did not seem to understand my presentation of the course content, and failed to see the planning towards the course objectives. Also they observed a lack of engagement from me as a lecturer. For many students the connection between what to learn and how it was taught did not make sense. My conclusion was that the lecturing, my lessons and the prepared laboratory work did not help them enough to prepare for the exam. In the literature I found many suggestions to solutions: communication skills, micro lecturing, problem and project based learning, flipped classroom etc. I decided to create a learning environment that focused on clear and outspoken goals and strategies to increase the motivation and understanding on what effort and skills the course demands. The hub of my practise became the Experiential learning theory (ELT) by David A. Kolb (2014). His explanation of learning as a process both individually as well as in groups constitutes the foundation from where I evaluate my teaching as a process that constantly changes and hopefully improves. Below I present the result from a survey done in the fall of 2015 where the students were encouraged to reflect on a part of a course in electronics which is considered to be really tough to pass.

RESEARCH QUESTION

What factors are crucial for students to find inspiration and motivation to work hard enough to pass the exam without making the teaching dependent on compulsory assignments? A trend that was spotted by the author was that teachers at our faculty use compulsory assignments to activate the students right from the start. One might argue that this could result in the students drowning in assignments and loosing their free will focussing on just passing the assignments. As a consequence the motivation to learn the content decreases. The main goal of this paper is therefore not to present a completely new method in teaching, but an example on how to increase motivation and inspiration to study by activating the students.

RESEARCH METHODOLOGY

When attempting to assess the effectiveness of a teaching method, the conclusions are not straightforward or clear. The reasons are individual differences in the learning styles of individuals, their background, and interest in the subject (Nagy and Sikdar 2008). Therefore investigations and research in situated matters involving people must be considered with great care. Clandinin and Connelly (1998) influenced strongly by Dewey in their research in learning and teaching, state the following:

"Experience is a key term in these inquiries. For us,

Dewey transforms a commonplace term, experience,

in our educators' language into an inquiry term, and

gives us a term that permits better understandings of

educational life. For Dewey, experience is both

' personal and social. Both the personal and social are

always present. People are individuals and need to be

understood only as individuals. They are always in

relation, always in a social context. The term

experience helps us think through such matters as an

individual child's learning while also understanding

that learning takes place with other children, with a

teacher, in a classroom, in a community, and so on."

One criterion of experience, according to Dewey, is continuity. Wherever you find yourself, you have a past experiential base that leads to an experiential future (Clandinin & Connelly 1998). So how does one investigate experience? Narrative inquiry helps one to draw conclusions from one's own set of data. Since all inquiries lack information about what parameters were involved, the conclusions shall always be interpreted within the context and what one can learn from it, is inspiration and suggestions on what to try for oneself, in one's own environment. It is not advisable to copy a method or conclusions like presented in this paper and think of it as a solution of the reader's own teaching process. For a more extensive description of the author's interpretation of narrative inquiry, see Staffas (2015:1)

The survey's main goal was to measure how the students experienced the more active learning environment that was intended compared to their previous courses and learning experiences in higher education. The content of the survey were strongly influenced by and related to the earlier inquiry in good spirit of Kolb's ELT (Kolb 2014). There were 54 students attending the course and all were invited to participate in the survey. The 38 that answered were also the most active students of the course. Experiences from the practise play a significant role for the conclusions in this paper. To make the responses from this year's students comparable with last year the content and planning was virtually the same. The small changes that were made were mainly from students' possibility to influence the planning.

DATA COLLECTION

From the two previous papers the following conclusions are essential and make the paper easier to understand:

The initial study revealed factors that made the students passive instead of taking part of the working plan, and also an analysis of what drives students to make the decisions on their attendance and effort. The interviews identified four different topics that stood out, the use of flipped classroom, the advantages of working in projects, the benefits and flaws from having all the teaching on a voluntary basis, and the need for structure. The students were exposed for online lectures on the basics, but the online lectures could cover more than that: procedural and conceptual new knowledge could easily complement the classroom teaching. That will help them to facilitate themselves using other canals available on the internet. The main focus is to make the studying cells as self-going as possible. This calls for a rigid structure at the beginning because otherwise many will get lost right from the start.

The teacher shall not take the role as an attendance secretary, but the inspiratory for the students to seek and explore.

Four types of students crystalized: The leaders, the followers, they who got lost and failed to catch up, and the lazy ones who couldn't sort it out.

The well guided projects worked fine in larger (6-8) groups. A common denominator between all groups of students is that the utmost first is a clear structure, almost regardless the content of the course. Therefore many mentioned the courses in mathematics as highly appreciated ones.

Using student active methods can free time to focus on methods to motivate and support the students to increase their effort and motivation instead of merely prepare lectures, lessons, seminars and laboratory experiments. The autonomy of the learner is the absolute key to motivation.

One of the most important reasons for failing the exam is grounded in a misbelief in how to study and how they learn. It is easy to step back and hold a low profile instead of starting a dialogue with the teacher when you lack confidence in your ability. (Staffas 2015:1 & 2)

There are several studies done in the field of electrical engineering. The use of simulation of circuits in the context of theory and measurements gives the students better understanding of the theory and motivate the students to use simulation software to analyze and design electronic circuits (Li and Khan 2004). Baltzis and Koukias (2009) show that the use of laboratory experiments and IT tools permits the students to acquire advanced knowledge and skills to develop realistic electronic systems and computer simulations, which proves to be highly beneficial in later courses. This calls for an early introduction of a method on how to attack electronic problem that is preferable used for the whole program. Continuity! In comparison with an approach trusted in traditional lectures and PBL as the intervention in teaching, PBL were found to gain twice as much in learning in comparing conceptual understanding on the tests (Becker, Plumb and Revia 2014). Assuming knowledge is holistic, Carstensen and Bernhard (2008) suggest a new model of complex context to identify and clarify "the troublesome elements" of the threshold concepts. In the model they identify "the pieces" of the threshold concept to learn and try to establish the links between the pieces to establish the knowledge relations. They discuss further and suggest three fundamentally different modes into investigation of threshold concepts: How to recognize a threshold concept? In what ways is it difficult and troublesome? And how do we find the critical aspects? They build their categorization of knowledge on Vince and Tiberghien (2002) that suggests a linkage between *Theory/model world* and *Objects and events world* and the learning is defined as skills, abilities, declarative and procedural knowledge. For further reading

Carstensen and Bernhard use the method presented in an electricity circuit course (2009).

To take the next step in the development of the author's teaching method, the model needed more data to explore. The survey's purpose was to examine how they experienced the different components of the model and how it benefitted their learning. Along with the questionnaire below they could freely express their thoughts and conclusions both in writing as in discussions with the lecturer. There was a formal invitation to discuss the course and their performance and results, and the more informal discussions that occurred during the semester. Notes were taken on a daily basis when discussions of the learning process took place.

THE SURVEY

In the questionnaire they were asked to compare their experiences with their previous courses. They could write freely any comment and what came up was that a wish for hand in assignments was mentioned by nine, more practical use of the theory by four and more quizzes by two. The students were clearly quite satisfied with the planning and the learning environments offered. They fancy being activated instead of lectured and have opportunities both to prepare themselves as to check what been learned. The main difference between this part of the course and their previous is that the lecture is just one small part of the chain in the learning process.

Table 1. The questionnaire and their answers

Question	Really good	Good	OK	Bad	Really bad	No score
The planning in general	3	27	2	-	-	6
Pre lecture and quiz as motivation	5	22	11 (which 5 of them did not use it)	-	-	-
The teaching is voluntary	12	13	10	3	-	-
	Really motivating	Motivating	Neither or	Less motivating	Devastating	-
Experience	10	25	2	-	-	1

from attending lecture prepared						
Working in groups	7	22	8	1	-	-

ACTIVE LEARNING

Active learning in this paper stands for a more student-centred approach than listening to a lecture or problem-solving lesson, and "fill in the blanks"-experiments. These are the most common teaching activities at the faculty where the study is performed. There is a distinction in "listening and interpret", and "analyse and explore" which I consider the border between passive students and active learning. Active learning calls for more than just listening and copying from the students.

THEORETHICAL FRAMEWORK: FACTS, PROCEDURES AND CONCEPTS

What to learn and in what way to learn it are topics that has been debated the last decades. Knowledge can be obtained with different approaches and when discussing deep learning compared to surface learning, conceptual and procedural knowledge is often mentioned in the context, sometimes even the assumption that procedural knowledge encourages surface learning. Anderson, Krathwohl and Bloom (2001) categorize knowledge as:
Facts – The basic elements students must know to be acquainted with a discipline or solve problems with it.
Conceptual knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together.
Procedural knowledge – How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.
Hiebert & Lefevre (1986) suggests that 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.
It is not clear how deep and surface learning relates to procedural and conceptual knowledge. In the last 20 to 30 years many researchers in engineering education points out procedural knowledge to be reprehensible (e.g. Pesek & Kirshner, 2000). Star (2005) proposes a redress for procedural knowledge and argues for a renewed focus on research on procedural knowledge. According to Star, Hiebert & Lefevre are only considering the algorithm part of the procedural knowledge, and not the heuristic, see below. Budd et al. (2005) claims that students have suffered from the fact that procedural knowledge are considered less important than conceptual.

Procedures can be algorithms or heuristic. This means that it can either be a step by step solution of a single problem, or gaining knowledge step by step using your own

intellection. Therefore it is too easy to just aim for conceptual knowledge in favour of procedural. It is very hard to distinguish them in practice. It is quite possible to be an excellent problem solver in both ways. Regardless of choice of gained knowledge, the author suggests that gained knowledge is hereafter better known as facts, whether it is an algorithm or a wider perspective in understanding a process. In the learning process, different concepts and procedures are presented using facts. It is possibly beneficial for the students to face the unknown clearly labelled "facts, "procedures" and "concepts". Simply putting the procedures in the proper context (supported by already known facts). For many students it will most certainly be impossible to see the whole in every taught field or subject. Not to mention how to predict which student learns what and how. Kolb (2014) suggests four different learning styles and that is an argument to form groups of students in their learning environment. By doing that you combine several learning styles and most likely increases the chance for the group to solve more problems and interact in explaining their findings. "Social interaction allows students to act as mediators of knowledge for each other" (Baltzis and Koukias 2009). This should make the learning more deep than shallow. The benefit from establishing a concept where knowledge is defined as facts makes the understanding of the curriculum much easier: "this we (should) know", "that we will have to learn", "this is the purpose of the module".

To search for a model that helps you promote deep learning, whether it is facts, concepts or procedures, the following description of a surface approach versus a deep approach to learning adapted by Crawley et al from the seminal work by Marton and Säljö (Originally published in 1976, see e.g. Richardson, 2005) should be carefully considered, see table 2.

Table 2.

A surface approach is encouraged by	A deep approach is encouraged by
An excessive amount of material in the curriculum	Student perception that deep learning is required
Relatively high class contact hours	A motivational context
A lack of opportunity to pursue subjects in depth	A well-structured knowledge base
A lack of choice of subjects and methods of study	Learner activity and choices
Threatening and anxiety-provoking assessment	Assessment based on application to new situations
A competitive environment	Interactions with others and collaboration

(Table 2.1, p. 14, Crawley et al 2014)

Many of the statements in the table are quite obvious, but it stresses that in deep approaches it is better to focus on a specific part of the content of the field. The

question must be: What is deep learning of the curriculum? For many students the time and the content are not there to see or get a grip of the whole. But they can still pass the exam learning procedures for a number of cases; in fact that is probably where most of the students end up. It becomes important for the teacher to make a decision on how to grade the knowledge of the course. Considering deep and surface approach to learning, one might argue that a teacher can implement or go for deep learning promoting both procedural and conceptual knowledge, but with a surface approach only procedural knowledge is possible. Like memorizing a short jingle to remember the prepositions that requires dative form of the noun in German, or learning to solve a linear differential equation in Engineering control to sketch the step response for a regulator. Nobody of these two gives a full understanding for the use of dative-form or how to solve linear differential equations, but they are necessary to understand a significant part of the process to get the whole picture of the process/system. One might argue that a teacher ought to address them quite simply as facts!

THE MODEL

The model is used in a course on 20 ECTS credits given on a semester on 2/3 speed. It is the first part which is the most theoretical and the hardest one for the students to pass. The students are encouraged to form groups of 6 to 8. That is because later in the course they work in projects and are encouraged to study in groups during the facilitated lessons in problem solving. Each part of the teaching and learning is voluntary. You can use compulsory assignments to force them to study but if you do so the students will not reach the absolute key to motivation: The autonomy of the learner. 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) and can be threatening and anxiety-provoking, see table 2. The raw material is divided into weekly themes (modules) with clear goals for each week.

1. Preparatory lecture on the internet
2. Conceptual lecture live
3. Lesson learning the conceptual fundamentals
4. Problem solving in groups towards course aims
5. Laboratory work consolidating the week's theme

For those who are more interested in the development of the model, see Staffas (2015:1 and 2).

The Preparatory Work

The preparatory lectures were highly appreciated. They consist of powerpoint presentations of the fundamentals needed to know to be able to put the matter into "real world problems". Each online lecture lasts no longer than 15 minutes. The students are invited to respond to the lecture via an online tool called Scalable learning (See http://test.scalable-learning.com/#/ for more information) that is developed for flipped classroom. A teacher can implement questions in the lecture as

well as follow up-quizzes in the program. Combining online lecture and quizzes provides the teacher with the opportunity to receive feedback on the material that shall be learned. It simplifies the decision of the level and selection on content for the live lecture.

Experiences: Although they are highly appreciated there are still very little information gained from the students to use in the lecture. Despite using an online tool, Scalable learning, many of them are satisfied looking at them on Youtube. The quizzes are not that popular. Since Scalable learning is designed for flipped classroom there are lots of benefits to gain for both the teacher and the students, so making them use this tool (instead of Youtube or similar) would improve the learning process and interaction between the teacher and the students. Later the author learnt that it is possible to make one's Youtube lectures untraceable forcing them to use Scalable learning. There are of course other alternatives for flipping your classroom with programs on the web. The online lecture has two purposes: 1. Make clear what facts that will be used. This is mainly from their previous courses and education. 2. Present the new components of the modules theme; this could be the basics for an operational amplifier in a course in analogue electronics. So when they attend class for a live lecture they know what facts they will be using in the presented new environment. The quizzes give them an immediate feedback if they understood the basics presented.

The Conceptual Lecture

The perception of importance is by far the strongest predictor of engagement, and also the most robust of perceived learning and attention (Shernoff 2013). This underscores the importance of teachers placing activities and course content in a larger context so that the students can appreciate the value of what they are asked to learn and do. They must clearly understand the importance of the activity for themselves and their future goals. It is important for the teacher to see the difference between establishing one's own goal as a teacher for the learning, and in the context of the students.
Other perceptions of classroom instruction highly related to engagement: Contributing valuable ideas, being active, and that the activity is useful to the learning process, also the perception of investing effort. In creating this learning environment they also need to feel that they are contributing members of the learning community.
The lecture discusses and handles the use of the new material. An outspoken goal is to try to explain and show how it is used in "real life". i.e. in what context and how it is supposed to work. It is important to discuss the concepts of the facts and what the consequences and benefits will be when applying the new material.

Experiences: Since the lecture´s goal is to become conceptual and hopefully more communicative there is a "risk" (chance) that it arises different aspects from the students that the lecture drift away from the prepared manuscript, although the conceptual content is still there. This can be experienced as "blurry" and "fuzzy" for some students; it seems like the burden gets lost in the process of answering audience questions/wonderings/proposals. Therefore it is of great importance to be absolutely clear what the lecture shall conclude within. By considering that it is nothing stopping you to quite freely throw away the manuscript making it close to a

performance instead of a controlled chalk and talk-presentation by script. It is all about preparation.

Discussion Presenting Concepts

In the conceptual presentation the modeling is important. One must find ways to model one's concepts to make them clear and easy to follow. There are of course more than one way to present the concepts and make them understandable. It is not too bold to use the term procedures in presenting the concepts; step by step gaining knowledge of a (whole) system.
Lesson learning the new concepts and procedures using facts
For many students there is a leap to right from the start imbibe the new concepts and perform on the level of understanding required by the course aims. Therefore it is many times better to divide the process in smaller steps giving them opportunities to establish a relation to the new concepts with easier tasks that helps them understand the fundamentals and getting closer to the new knowledge. This type of learning is best performed in classroom under supervision since it is the first time they really try to use the new concepts.

Experiences: When considering the knowledge to be learned and what tasks that will be most suitable it becomes more clear for the teacher where the obstacles are and can focus on them in this first step of problem solving. Also this will be an excellent opportunity to identify new facts, procedures and concepts that are possible on the way to the modules final knowledge, i.e. the course aims.

The Group Work

Plenty of time is needed for the students to go through the stages to create new facts. They cannot have a teacher or tutor all the time of the progress so together in groups can be a forum where the problems can be discussed and processed. Until now the author facilitated them, always in the neighborhood ready to help them when they get stuck.

Experiences: There are numerous examples in research about the tutor's role in PBL (see for example Azer 2005). A more extensive study on the development of the group work and its progress in relation to a facilitator is called for. The starting point could proceed from Kolb's learning styles how the group develops. In the survey the formation of the groups were decided by the students copying the model used in PBL at Aalborg University's engineering programs. Therefore I am careful jumping into conclusions on how to perfect or at least develop the process of the group work. In a voluntary perspective it must be the students' choice to form groups and take advantage of the dynamics grouping can give. A clear path for their study towards the course aims might be enough and this part is maybe better left alone therefore.

Laboratory Work To Conclude The Knowledge Of The Module

According to Shernoff (2013) and consistent with learner-centred and constructivist approaches, the teacher can achieve these goals by having students explore and experiment with the content and relate to their own experience (Weimer 2002). The goal is to create independent learners (Boud, 1981)

As the course reported on in this paper is one where they could work in the laboratories with the content, the headline appear obvious.One might argue that the laboratory work can be perceived as a metaphor for other activities: it could be seminars, workshops, cases, or simply just problem solving to give the student a receipt on what is accomplished during the modules work. For a teacher, issue with practical applications, either simulated or with real circuits can arise. The groups have been encouraged to summarize the modules work and reconnect on the summing up part starting the next module. Questions that remain could be handed in to me as basis for the summing up to come.

Experiences: Students fails in the summing up part of the module. One might suggest two major changes that mightsolve many of the issues in tying the bag together: 1. The students must have the opportunity to test themselves during conclusion day. 2. To summarize the module they are allowed to hand in a written document where they summarize their newfound knowledge to help them remember what been taught. Earlier year they have been encouraged to write their own "cheat sheet" as a process during the course, with varying success. By changing to a document that is created, and finished, during each module they do not only have to value their progress, but also a huge carrot for them towards exam is exposed: no work means nothing to hand in to help them at the exam. So the conclusion day shall contain: tasks that practically confirms the theory of the knowledge, a seminar where they can discuss problems they fail to sort out with a teacher, a quiz to control their newfound knowledge, and a hand in of their own "cheat sheet" they wish to use on the exam. Important for the next module is to be as careful as before to point out what concepts and procedures that now is considered as facts in the next module of the course.

CONCLUSIONS

Considering my experiences all the teaching and learning activities could be held voluntary; the opportunity to create your own "cheat sheet" becomes a carrot as well as a whip. A teacher can concentrate on creating the smorgasbord of activities leaving the responsibility almost entirely on the students. Time spent reading reports from compulsory events can be used more efficiently. 25 (in reality 29 since four of them who answered "Doesn't matter" commented that they attend on everything anyway) of 38 in 2015 thought it is at least good that all the teaching was voluntary. Thirteen of them commented the flexibility as an advantage because you could choose what was worth attending. Only 3 of 38 thought it was no good, commenting that it requires self-discipline (!).
What about organizing your course with compulsory assignments during the course? Is not that a method to get the students going right from that start and make your practice smooth and appreciated? Some teachers include assignments on a regular basis making the students´ work hard directly from the start and to some extent become rather successful. The students' reaction is positive in a sense that they have to work hard from the start of the course and naturally becomes more prepared for the exam. Another advantage is that it is clearer what the demands for passing are. There is also two major issues to take into consideration, namely if all the courses had this planning the burden would probably be too much for many of them, and 2nd is that there will be a whole lot of work for you as a teacher grading assignments. For me personally it is not something well in harmony in teaching

students of age in higher education; part of it is to realize the responsibility to become self-regulated learners. So to ease your burden and still offer good learning environments where it is up to the students to take full responsibility for their path towards exam, the above presented model and considerations not only reduces your own achievement in time spent grading and reading assignments, it also helps you to spend more time with the students in their learning process.

The utmost important component to succeed in creating learning environments based on their own motivation and inspiration is a clear structure on how to reach the course aims. The survey supports different activities creating active learning instead of just "chalk and talk". Just implementing active learning activities as described above is not itself a guarantee to help the students to pass or get better grades, but helps you in the process to make the students more self-going and enjoy their studying more. What really stands out is the desire to start their own projects with their new-found knowledge. There is a group of students that still struggle to pass the course and one way to increase their chances could be to more in detail describe the new content and how to get there. An inquiry will be made on implementing online lecturing that includes working with concepts and procedures, besides just learning new facts. An important and central tool in the process based on previous studies mentioned above should be simulations of key concepts.

DISCUSSION

Consider Kolbs ELT and the legacy of Dewey, Lewin and Piaget "as the foremost intellectual ancestors of experiential learning theory" (Kolb, 2014, p. 15) and apply that on modern higher education. More and more students struggle to pass courses mainly due to the inability to focus and work hard on things that involve learning new facts based on concepts and procedures. The following model is considered to be fairly straightforward to use and, what really stands out, is understandable for almost all students that pay some attention: After presenting the course and its objectives the teachershall divide the content into modules which has a clear base of facts that will be used in a context, mainly (all!) conceptual. Present the facts and the context in which they will be used. Use the proper context to present the concepts to learn. State the new facts that come out of the concepts based on already known facts. If the material is possible to realize in practice, do that. And the most important part of them all: Let the students hand in their own new facts written down in their own words to be used at exam. This is a practical approach that considers all aspects of teaching: Clarity, structure, ELT, whatever used active learning theory, 100% responsibility for the student, and a possibility to try out the theory in practice AND formulate the new knowledge hereafter known as facts. After one module you just formulate the next in the same way. The whole course (a semester, set of courses, even a whole program) is now a 100 % transparent chain of facts to use and to learn using active learning, whether you are a procedural or conceptual learner.

This becomes even more important if you trust that conceptual thinking is independent of an individual´s ability to use procedural knowledge (Baker & Czarnocha, 2002). Since the students become aware of what procedural knowledge to gain they must make sure they reach it, no matter what it takes. This makes the teaching and learning facilities more interesting and just knowing that should increase motivation, or at least make them more aware of their own responsibility. If

they do not reach the next level of facts it becomes hard to hand in notes for the exam since they have not reached the level of understanding conceptually.

The paper focuses mainly on conceptual knowledge. However it is not obvious that just concepts are the learning outcomes to strive for. In the new taxonomy Anderson, Krathwohl and Bloom 2001) knowledge are represented as facts, procedures, concepts and metacognitive learning. A broader survey focusing on all or more than one of these knowledges is desirable. Some of this is discussed in a future paper.

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Heuristic for learning Common Emitter amplification with bipolar transistors

Mathematics in engineering education causes many thresholds in the courses because of the demand of abstract conceptualization. Electronics depend heavily on more or less complex mathematics.. Therefore the concepts of analogue electronics are hard to learn since a great deal of students struggle with the calculations and procedures needed. A survey was done focusing on students' battle to pass a course in analogue electronics by introducing a top-down perspective and the revised taxonomy of Bloom.

From a top-down perspective you can create learning environments from any spot in the taxonomy using a step by step approach of the verbs *understand* and *apply*. Three textbooks with a top-down perspective on analogue electronics are analysed on the concept of amplifying with a transistor circuit. The study claims issues in losing the top-down perspective when presenting concepts and procedures for the content to be learned.

Keywords: top-down; facts, procedural and conceptual knowledge; deep and surface learning; heuristic.

Goal

The main purpose of the paper is to show a direct application of the taxonomy and how to, step by step, eliminate some of the thresholds many students experience in electronics. This is done by breaking down the learning outcomes into simple facts, procedures and concepts to the levels of *understand* and *apply* in the taxonomy, ensuring more students are capable to learn more complex electronics. This should clarify and highlight the new concepts so they do not disappear in the process of learning procedures for the necessary calculations.

Top-down and Bottom-up

In a top-down approach the whole system to be learned is presented before its parts are exposed. If the content is amplifying you consider first the characteristics of amplifying in general and its electrical properties, before you actually describe how to design one with electronic parts. The electronic parts fundamental properties may then also need to be explained, in consequence as a system, before it is explained in more detail. In a bottom-up approach you start with a phenomenon that gives an electric behavior that can be used as a component, for example the pn-junction that can be used like a diode and in extension a transistor. The process of demonstrating the physics of electrically charged materials to the diode and transistor and later its use in amplification is therefore a bottom-up approach in teaching.

Introduction

In a system approach of analogue electronics the focus is mainly on the amplifying circuit as the system. The amplifying circuit is later actualized with an operational amplifier (OP) or a transistor. The common emitter (CE) circuit for amplifying with a bipolar transistor has been spotted as one of the hardest to learn since it includes both advanced concepts (instances Ohms law is not valid) as well as difficult procedures to apply, mainly because the circuit is designed with a direct current (DC) starting point that is replaced with a modelled alternate current (AC) circuit when the DC statics are determined. The students participating have studied the textbook and experience that they have not understood the connection between the DC and AC properties of the CE amplifier. All three textbooks chosen in the study are used at the department of engineering in Uppsala University. They are Electronics – A system approach (Storey 2013), Analog elektronik (Molin 2009) and Microelectronics (Sedra and Smith 2016). After almost all previous textbooks began with the pn-junction (solid state electronics) and the diode moving further to the transistor and its futures, the top-down perspective has been dominating for the last 15 years. In analogue electronics that means

starting with the problem of amplification of a signal, introducing the OP, and explain the electronics from signals that will be amplified. That means using Kirchoffs laws (KI and KII), Ohms law, and circuit laws like superposition and mesh analysis to calculate the output from an amplifier. The variables are voltage, current and impedance.

After studying circuit theory on voltage and current sources with resistors, capacitors and inductors, reaching a steady state, the next step in analogue electronics is to consider the signal amplification in active circuits. There are thresholds concerning frequency responses using an operational amplifier for signal conditioning (using relatively advanced mathematics in the analysis), and when the amplifier is replaced by a transistor you need to first consider the DC properties of the circuit to prepare for AC amplification in the frequency domain. The step from design and dimension of the DC circuit needed for the amplification to analyse the properties of the circuit in the frequency domain is something lots of students struggle with. A key point is to understand the working point decided for the CE circuit, and how the resistors' values affect the AC properties in terms of what amplified signal you can receive. To understand this most textbooks presents a relation between the current through the transistor, I_C, with the voltage over the transistor for different control currents on the base, I_B, see figure 1.
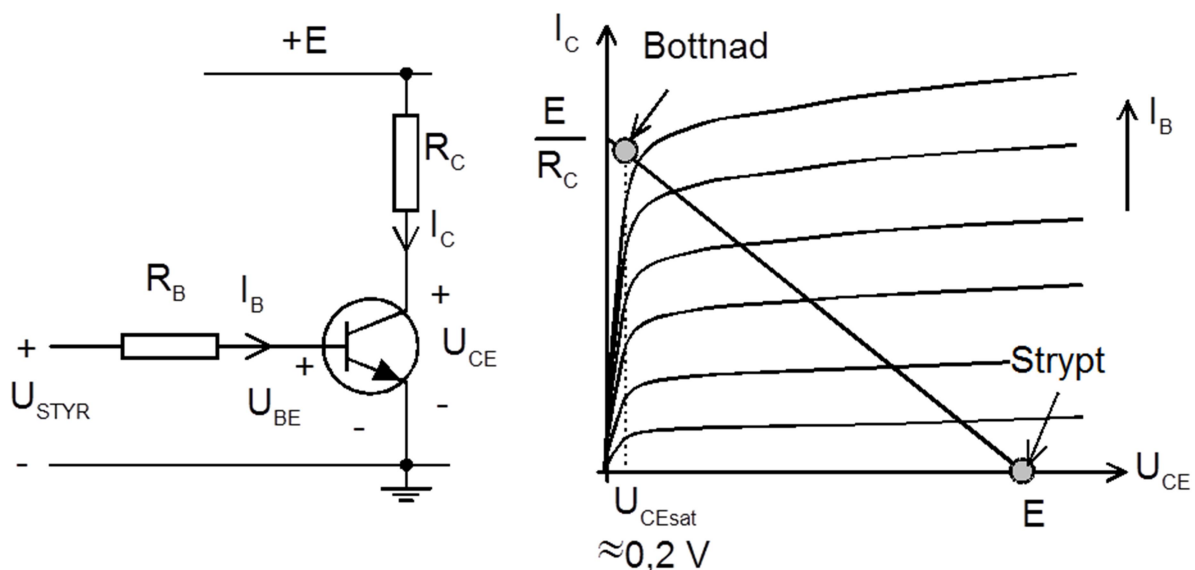
Figure 2: Relationship between the current through the transistor and the voltage over it for different base currents, I_B – courtesy of Bengt Molin

Literature review and theoretical framework

Computer-aided simulations help the students to test the components in circuits much more time efficiently than on the circuit board in the laboratory. The use of simulation of circuits in the context of theory and measurements gives the students a better understanding of the theory and motivate the students to use simulation software to analyze and design electronic circuits (Li and Khan 2004). Baltzis and Koukias (2009) shows that the use of laboratory experiments and IT tools permits the students to acquire advanced knowledge and skills to develop realistic electronic systems and computer simulations, which proves to be highly beneficial in later courses. This calls for an early introduction of a method on how to attack electronic problems that is preferably used for the whole program, providing continuity in the practice. In comparison with an approach trusted in traditional lectures and PBL as the intervention in teaching, students in a PBL approach learned twice as much in comparing conceptual understanding on the tests (Becker, Plumb and Revia 2014). Assuming knowledge is holistic, Carstensen and Bernhard (2008) suggest a new model of complex context to identify and clarify `the troublesome elements´ of the threshold concepts. In the model they identify `the pieces´ of the threshold concept to learn and find the links between the pieces to establish knowledge relations. They discuss further and suggest three fundamentally different modes into investigation of threshold concepts: How to recognize a threshold concept? In what ways is it difficult and troublesome? And how do we find the critical aspects? They build their categorization of knowledge on Vince and Tiberghien (2002) that suggests a linkage between *Theory/model world* and *Objects and events world* and the learning is defined as skills, abilities, declarative and procedural knowledge. Carstensen and Bernhard (2009) use the method presented in an electricity circuit course using variation theory for the tasks and the analysis of the task structure. That study is therefore not similar to this but still

interesting because although they changed just one primary parameter at a time, several changes could occur in the system's response. In their conclusions their results indicate that the theory of variation can be useful when designing new learning environments and to improve existing ones, learning more complex concepts. This could well be adopted in the process of this study. In 2001 Andersen, Kratwohl and Bloom published their revision of the taxonomy of educational objectives by Benjamin Bloom (1956). The original taxonomy defined six major categories in the cognitive domain: knowledge, comprehension, application, analysis, synthesis and evaluation. All but application were then further broken into subcategories. The categories were ordered from simple to complex and from concrete to abstract. To advance you were required to master each of the simpler categories. The taxonomy was adopted by many and was used to classify curricular objectives as an example. In the revision the one dimensional taxonomy was extended with a second; the knowledge dimension. The categories are facts, concepts, procedures and a metacognitive level. Basically the knowledge dimension highlights the nouns of knowledge and cognitive the verbs. Therefore *application* became *apply*, *analysis* became *analyze* and so on.

Table 1 – The taxonomy table

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual						
Procedural						
Metacognitive						

The level of complexity and the kind of process decides where each learning objective ends up in the table. The table then gives an indication of how difficult the content is. It is an attempt to categorize knowledge and it helps you understand the nature and complicity of your learning objectives. Originally the taxonomy described the steps needed to understand a problem/area. The different types of knowledge were introduced to include learning goals in a course, and the writers carefully explain how to analyze your learning goal and where it will

end up. The problem is partly to rank the learning goal, and partly how to get there with your teaching. Learning goals can however contain both procedural and conceptual knowledge; sometimes it is possible to reach the learning goal in both ways. It is all about how you choose to grade the knowledge. In a written exam it is quite possible to solve a problem in more than one way; one can be strictly procedural while the other using concepts, or a mix in between.

An example: Decide a proper working point for the CE amplifier (figure 2) when $A_V=3$. There is a procedure where you start with the voltage divider on the base that decides the U_E and then U_{CE} via U_C. This means that I_C can vary some depending of the choice of U_B and in some cases even become completely wrong. But experience (or pure luck) makes this a possible procedural way to a proper solution. On the other hand you can determine a current suitable for the transistor and its application. With a chosen voltage supply (V_{CC}) you know that U_{CE} shall be approximately 40-45% of V_{CC} and get I_C from there. A voltage mesh gives you the proper U_B and you can calculate the voltage divider on the base from there. This requires more knowledge about the transistor and its properties, and gives a more solid solution. It is thus more conceptual. By introducing the top-down-perspective the goal for the learning outcome becomes very clear. The path towards the learning outcome from prior knowledge is mapped out, via facts, procedures and concepts. This study focuses on the knowledge dimension and described as facts, procedures and concepts, the learning goals can be considered both in terms of verbs and nouns (of facts procedures and concepts). The Meta perspective comes partly from the ability to understand the relation between procedures and concepts and partly from applying the new knowledge on other problems. Using a top-down perspective gives students at least the knowledge on how to apply in this case the CE amplifier in its basic design, and also of course the opportunity to understand the expansion of its use. If you just use Ohms and Kirchoffs laws for current and voltage in the circuits you can calculate any DC properties for the CE amplifier circuit. The learning process of the DC

properties was exposed in steps with facts, concepts and procedures that would give the knowledge to determine the suitable DC properties of a CE amplifier and calculate the AC amplification as well as the input and output resistance.

Review of the textbooks in electronics on CE amplifying with bipolar transistors
Storey: Electronics – A system approach, 5th ed.

The book is presented in two sections: Electrical circuits and components and Electronic systems. A companion website is available which contains more than 100 Video tutorials to provide guidance and encourage creativity, and self-assessment exercises for each chapter. There are also a large number of Computer simulation exercises supporting the material in the text. For the Instructor there are editable PowerPoint slides plus an Instructors manual with fully worked solutions to all problems. There is also a guidance on course preparation to meet the students' needs with different backgrounds. Key points summarise every chapter. In the foreword the author emphasizes the "top-down" approach of the content and compares it with a "bottom-up" approach that was common when the 1st edition came out (1992).

The author chooses to present the field effect transistor (FET) and its properties first. So they are already familiar with the transistor function in a number of circuits such as amplifying, switches, constant current sources, differential amplifiers, negative feedback and so on. Operational amplifiers (OP) have been presented and filter design mentioned, but only the DC relation between input and output with negative feedback is computed. So the top-down perspective intention is probably that the OP circuits are presented before the transistor. In the beginning of the bipolar transistor chapter the author deviates from the top-down perspective: The transistor is presented as a current-controlled device, in comparison with the voltage-controlled FET. The relationship between the base and the collector current (linear) and the npn- and pnp-construction of the transistor. The notation is labelled and then the basic characteristics are presented (figure 3 and 4). $I_C = h_{FE} I_B$, $i_c = h_{fe} i_b$ and $g_m = dI_C / dV_{BE}$

are defined, as well as a simple amplifier (figure 5). The transistor configuration of the common-emitter with the input (figure 4) and the output characteristics (figure 6) leading to transfer characteristics are described in two ways: the first in terms of the current gain, and second in terms of its transconductance. A comparison with the FET amplifier is suggested (referring to the corresponding figure of dependence between the controlling voltage (i.e. U_{BE}) and the drain current (i.e. I_C). The difference between the active (h_{FE}=approximately linear) and the saturated region are explained. In an ideal transistor the active regions curves would be horizontal, and the deviation is the output resistance. The leakage current when $I_B=0$ is defined and explained as `usually negligible´. Referring to the relations between output and input current and output current and input voltage, the relations between I_B, I_C and I_E is explained using KI and h_{FE}. The expression of g_m, r_e and h_{ie} is calculated. Then the small signal equivalent circuit for the transistor is presented.
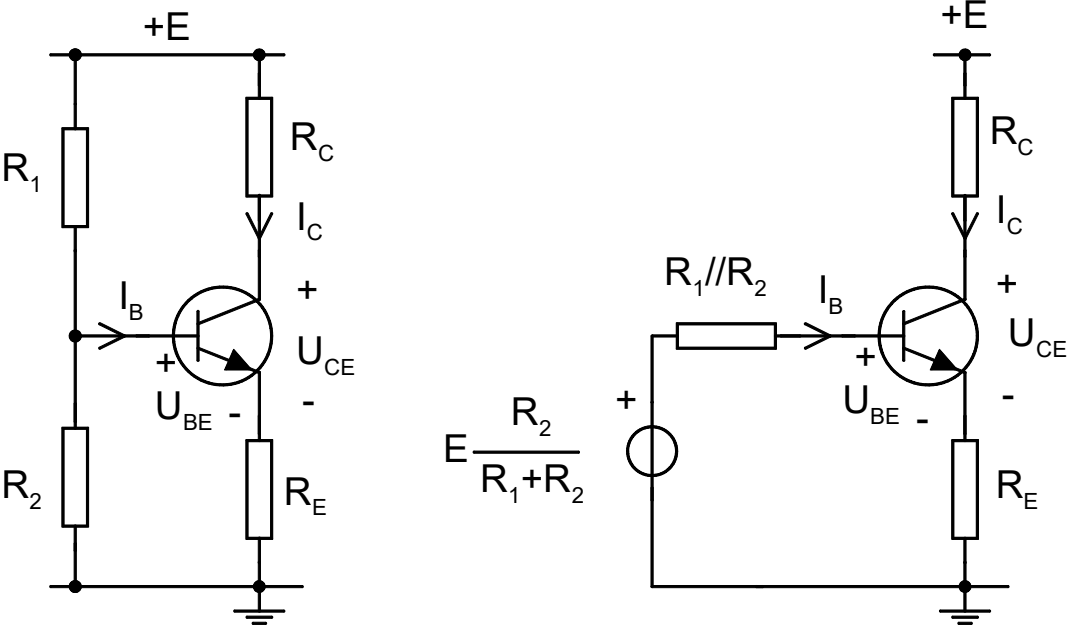

Figure 3: Working point approach with a voltage divider on the base – courtesy of Bengt Molin
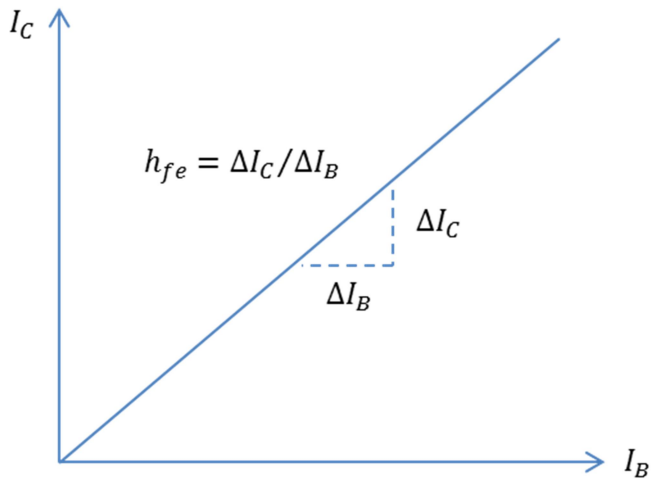
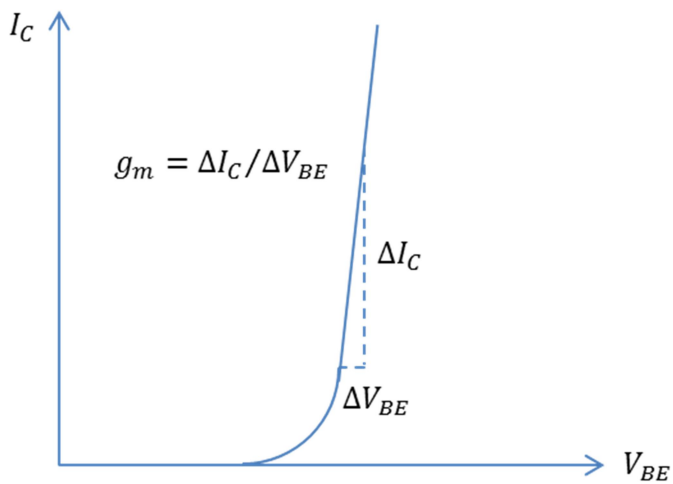Figure 3 – Relationship between the collector- and base-current.

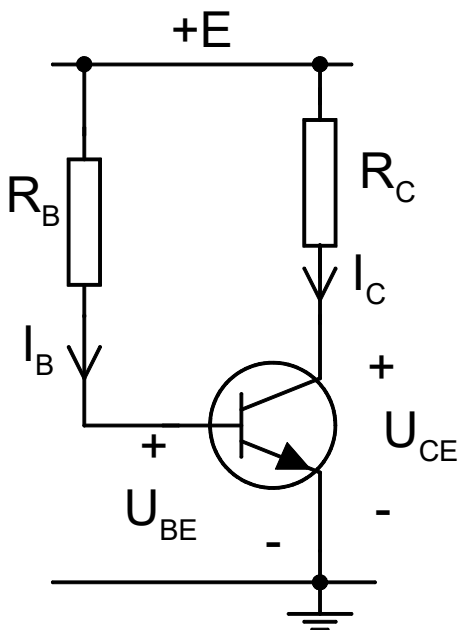Figure 4: Transconductance, g_m, for the transistor

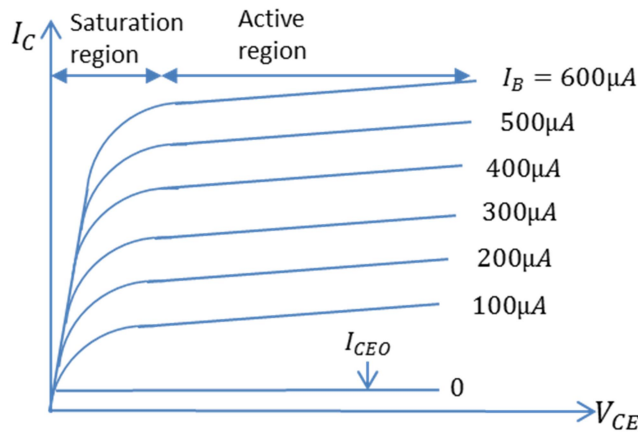Figure 5: A simple amplifier – courtesy of Bengt Molin

Figure 6: Output characteristics for the amplifier in figure 5

Molin - Analog elektronik 2nd ed.

Like Storey he emphasizes the system approach he uses in his own teaching since the middle of the 1990's. There is a website with all the figures in the book free to use in the teaching, and complete solutions on each problem is also provided. Implicitly the book has three main parts: The amplifier, applications of the transistor and the OP, and high frequency technique.

The book starts with describing electronic systems in blocks and exemplifies some of them. A general amplifier is presented and then the OP. The OP AC amplifying circuits are reviewed and analysed. So before the transistors are presented both the DC and AC properties of the OP amplifier are exposed. In the first edition he presents the bipolar transistor first, but that is changed in the 2nd. So, like Storey, the FET is the first transistor circuit. His approach is very similar to Storey: The component is exposed from a bottom up-perspective ending with the applications. So before the transistor the diode and the pn-junction are presented. One difference to Storey is that Molin does not use the term `active region´ but explains that the transistor saturates when the current I_C is high enough for the CE circuit. The amplifier as a simplified CE amplifier is analysed and dimensional and the working point is motivated with the diagram in figure 7.
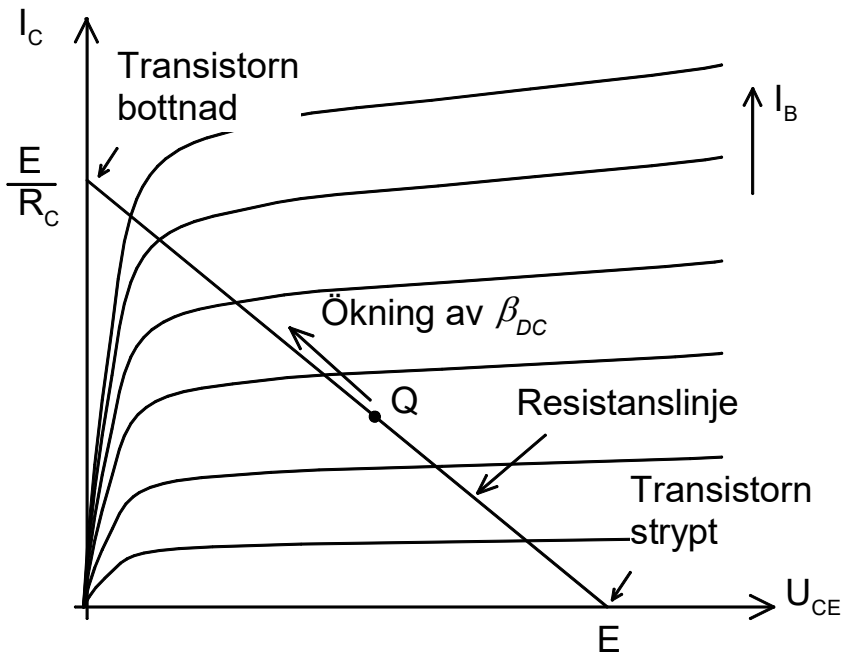
Figure 7: Working point diagram – courtesy of Bengt Molin
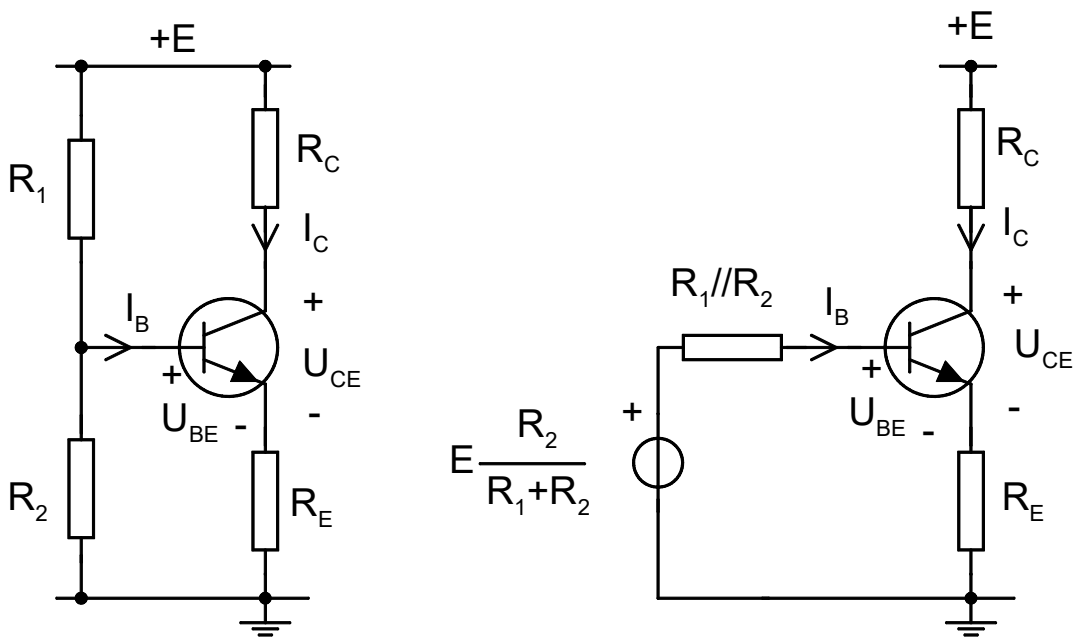

Figure 4: Working point approach with a voltage divider on the base – courtesy of Bengt Molin

From the simplified CE amplifier (figure 5) the base current I_B is determined by R_B and hence I_C will depend on I_B and $\beta(=h_{FE})$. This moves the working point in the diagram (not wanted). The circuit in figure 2 is motivated since it stabilizes the working point. The Q point

does not move because of R_1 and R_2. Thereafter the signal scheme and its properties are presented.

Sedra/Smith – Microelectronics circuits 7th int. ed.

The book is divided into four parts: Devices and basic circuits, Integrated-circuit amplifiers, Analog integrated circuits, and Digital integrated circuits. The design is emphasized. On the website an extensive appendix of a large number of simulation and design examples are presented. Further it contains Data sheets for hundreds of devices, links to industrial and academic websites, a message centre for communication with the authors, step-by-step guidance to help with the simulations, and bonus text materials of specialized topics not covered (or just briefly covered) in the text. Suggestions on Course organization and an outline for the reader is provided in the foreword. For the Instructor an Instructor's solution manual, PowerPoint-based figures and detailed support for the circuit simulations are provided.

The authors' goal is to emphasize the design with components. Amplifiers are presented as circuit building blocks like in Molins book. The pn-junction is treated before the OP. The applications of the OP are immediate and its futures are included in the presentation of the different applications. The next chapter presents the diode and then the transistor is introduced. The transistor is examined with equivalent circuits but basically the content and planning is similar to the two textbooks above. The presentation of the CE amplifier circuit is however from using the U_{BE} pointing out the saturated and the active region of performance, like in figure 6 and 7. The explanation of the working point diagram is much more thorough with several examples and diagrams. The student is encouraged to verify the Early effect and the necessary values on U_{BE} for the transistor to operate in the active mode, at the edge of saturation, and deep in saturation with $\beta_{forced}=10$. Starting point $U_{BE}=0,7$ V constant and $\beta=50$. The next example considers the circuit with different U_B and an emitter resistance, R_E. This is another example to show how the transistor can be saturated and therefore I_C and I_E will

differ. A number of different circuits similar to the previous are shown and points out the effect of how the voltage on the base affects the currents in the transistor connections. It is all about creating knowledge on how the DC currents and voltages on the transistor behave. Both the pnp and the npn is used in the circuits. Then the MOSFET is presented followed by the amplification chapter.

Comparison of textbooks

Storey and Molin claim to use a system review of the amplifier. It is true that they all start with the amplifier as a mystery box and thereafter exemplifies it with the OP. Sedra/Smith starts with a circuit configuration and pointing out the various trade-offs available when selecting component values. When Storey and Molin moves directly towards the CE amplifying circuit explaining it from the workpoint diagram, Sedra/Smith chooses to exemplify the relationship between the DC voltages and currents through a large amount of examples, mainly due to what voltage is on the base. They use the diagram to show that different U_{BE}'s give different I_C's in the active region, and spend a lot of pages and examples investigating the saturated region. The amplifying property is not discussed or mentioned. Exams show that students in general cannot go directly from the DC characteristics to the amplifying stage just by studying the workpoint diagram and the relation between different I_B's and I_C. Sedra/Smith solves some of the issues not presenting the AC amplifier in this context. They focus on the reader getting a feel for the differences the transistor itself creates in the DC application. Sedra/Smith provides a good base for understanding KI and KII for the transistor, but basically it is a bottom-up approach. The step from introducing the transistor and its DC characteristics to the AC amplifier is a huge threshold for most of the students, and the students in the survey all claimed that they did not understand the application of the workpoint diagram to understand the dimensioning of the CE amplifier and how it was connected to the AC amplifier. The students in the survey used Molins textbook in their previous course.

An alternative way – top-down

Begin with the CE amplifier in its fundamental form, see figure 9 in test below. Explain how to calculate the gain, the input and the output resistance, referring to the OP amplifier circuits and explain the difference (mainly AC performance). You only need to assume β which could be motivated by examples where they measure I_C and I_B. Simulate some cases of amplification and compare with the results suggested from formulas. Give them examples where the working point matter, i.e. the output signal is distorted due to the DC level of the collector. Show how to calculate the DC potentials with KII. Measure the DC characteristics for a circuit in a simulator. Apply KI on the three transistor nodes. What is your conclusion? Change the values of R_1 and R_2 dependent of each other, as well as random values and measure the voltage over the transistor, U_{CE}, and R_C. Now some conclusions regarding the relation between the voltage divider and the voltage over the transistor is easy to establish. Now it is time to introduce the AC equivalent circuit and derive amplification and input and output resistance.

$$U_{ut} = -40I_C \cdot R_C$$
$$R_{in} = R_1 // R_2$$
$$R_{ut} = R_C$$
Calculate the gain

Simulations

Simulations

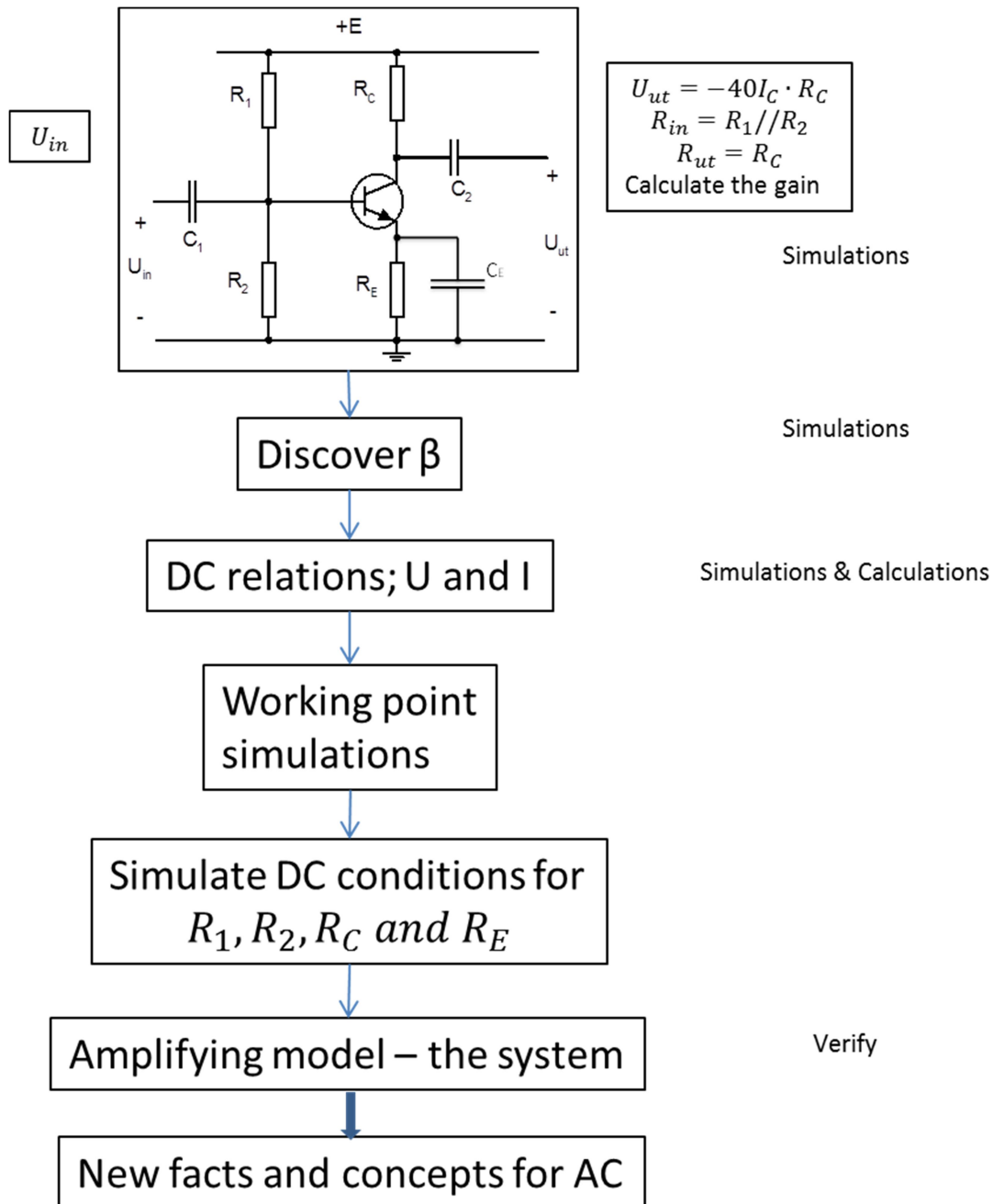Simulations & Calculations

Verify

Figure 8: An alternative way – top-down

When the DC and AC properties are justified the properties of the transistor can be thoroughly discussed. The proposed model has two advantages: First it is still the top-down perspective, and 2nd if the students do not learn the properties of the transistor, they will still be able to use it as an amplifier of small signals.

Research question

Even though a concept or procedure is considered to be high up in the taxonomy, is it possible to break down the content of instruction into facts, procedures and concepts, according to the new taxonomy, to the cognitive stages of *understand* and *apply* in order to learn it better?

Methodology

The survey was made during the spring break, i.e. between the two periods of the 2nd semester. It interfered with the exam period for the students, explaining why the majority of the students chose not to participate. No other time period was possible for the students. The teaching and learning was limited to three online instructions with two seminars discussing their experiences. The mini course finished with a voluntary test and they were encouraged to write down their thoughts and hand it in with the test. When receiving the marked test they were interviewed by the author about their newfound knowledge and time spent studying. The students finished the actual course in October and had a rest exam in January. The mini course began at the end of March.

As can be noticed in the first lesson below the content begins with a description of the circuit being taught. In the survey the AC amplification was not mentioned since they already know the purpose of the circuit in terms of amplification of periodic signals. The content was broke down into steps where the student could use earlier knowledge, presented as facts, together with the new concept. New knowledge was presented either as a procedure or a concept and its application using `understand´ and `apply´. Their test result, written down experiences and an interview was the data collected for the survey, beside the textbook analysis.

Table 2 - Summary of the planning and attendance

Session	Time	Participants
Online lesson 1 and 2	Estimated 3 hours	
Seminar 1	90 minutes	All
Online lesson 3	Est: 1½ h	

Seminar 2	60 min.	All but student 4
Test	2 h	All
Individual interview	10-20 min	

The content - one of the three lessons

Lesson 1: Presentation of the goal: Learning to dimension the CE amplifier and calculate the gain, input and output resistance with or without the decoupling capacitor C_E, see figure 9.
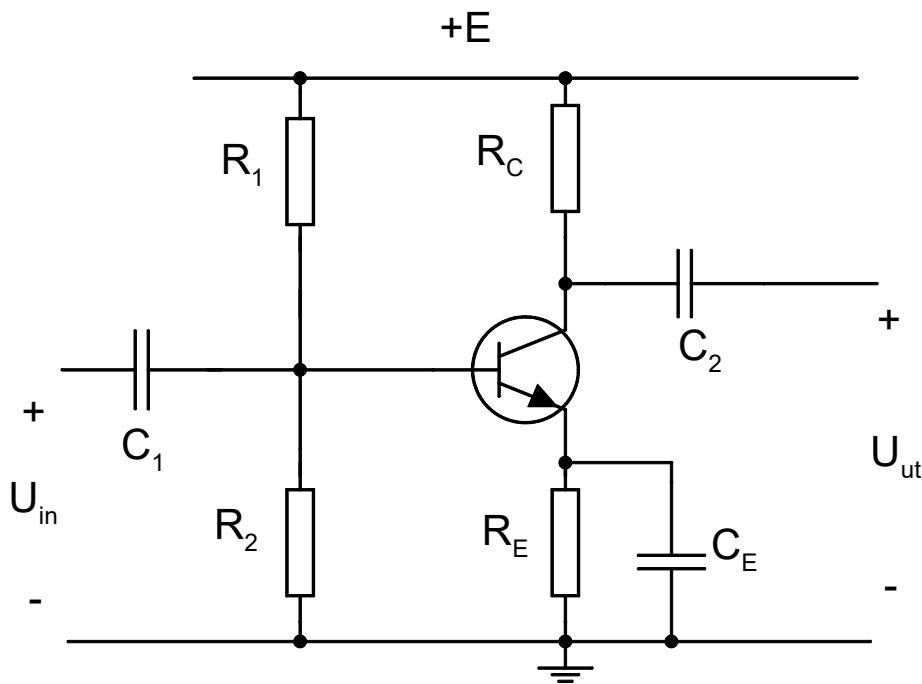
Figure 9: The CE amplifier – courtesy of Bengt Molin

Next step was to establish what they know in circuit theory to analyze the circuit; Ohms law and Kirchhoff's voltage and current law. The terms fact, procedure and concept were presented and explained as different levels of knowledge. First task: Understand the relation between U_{BE}, I_{BE}, I_C and U_{CE}. From the circuit in figure 9 they were instructed to vary the voltage U_{BE} and measure the three other and mark down the values when they received max and min, and answer the question of the maximum value of I_C and why. Finally they should determine with what value of U_{BE} U_{R1} equals U_{CE}. So they established the fact that U_{BE} determines a specific value on I_C. What happens if R_C changes? Testing show that it is

still the same and they were told to measure the voltage U_{CE}. So now they know that I_C does not change, and I_B is also the same but U_{CE} changes. So regardless of R_C U_{BE} gives the same I_B and I_C and $\beta = I_C/I_B$. The reason for the change of U_{CE} is an application of Ohms law over R_C and a voltage trek from +E to Ground.

Conclusion: A certain U_{BE} determines I_B and thereby I_C. Accordingly the value of R_C decides the voltage over R_C (which gives U_{CE}) through Ohms law. The next two lessons were similar and the last instruction was merely a more complex problem to solve.

The test

The first two are the control questions. One is a system of equations necessary to calculate the results from the use of Kirchoff I and II in analyze the circuits. The other is an electric circuit where they need to use KI and II to calculate a current and a voltage over a resistor. Something they should know from previous courses. The third was a clear conceptual question where they should use KI and II to calculate currents and voltages in a CE circuit. 4. Needing both procedural and conceptual skills to reach a solid solution. 5. Just understand the difference between decoupled and not decoupled emitter resistance. 6. A circuit where the usual ratio between base and collector current isn't valid. They should spot that by using KI for the transistor. The level of the test is not simple: two of the assignments are for top grade, and only one needed just the right formulas. The slightly more difficult questions were chosen to make sure it was not too easy, and that it was a small part of the course which should make the remembering easier.

Known facts: $A_V \approx -R_C/R_E$, $A_V \approx -g_m R_C$, $g_m \approx 40 I_C$ and $U_{CESAT} = 0,2$ V. β can differ.

1. Solve the system of equations

a) $\begin{cases} 3x - 3y - z = 1 \\ 3x - y + 2z = 2 \\ x + 2y + 3z = 3 \end{cases}$ b) $\begin{cases} 2x - y + 1 = 0 \\ x^2 + y^2 - 10 = 0 \end{cases}$

2. Calculate I_{R2} and V_A in the figure.
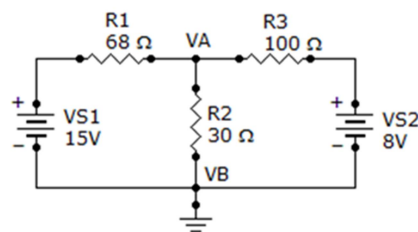
3. Determine the quiescent point for the circuit
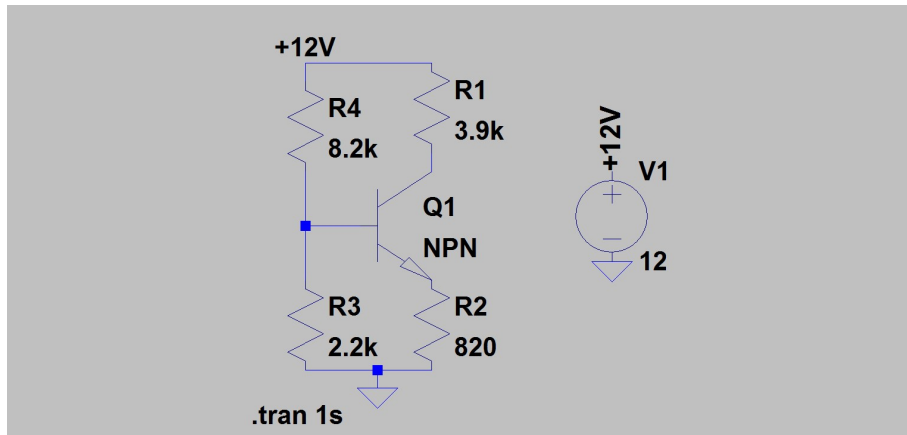
4. Design a CE amplifier with 7 times amplification. I_C shall be approximately 1 mA and 12 V voltage source is available. The resistor values do not have to be according to E12. $\beta=200$

5. If the emitter resistance is decoupled, what is the amplification? If you did not solve A4 you can use the circuit in A3.

6. Calculate all currents in the circuit. $\beta=100$
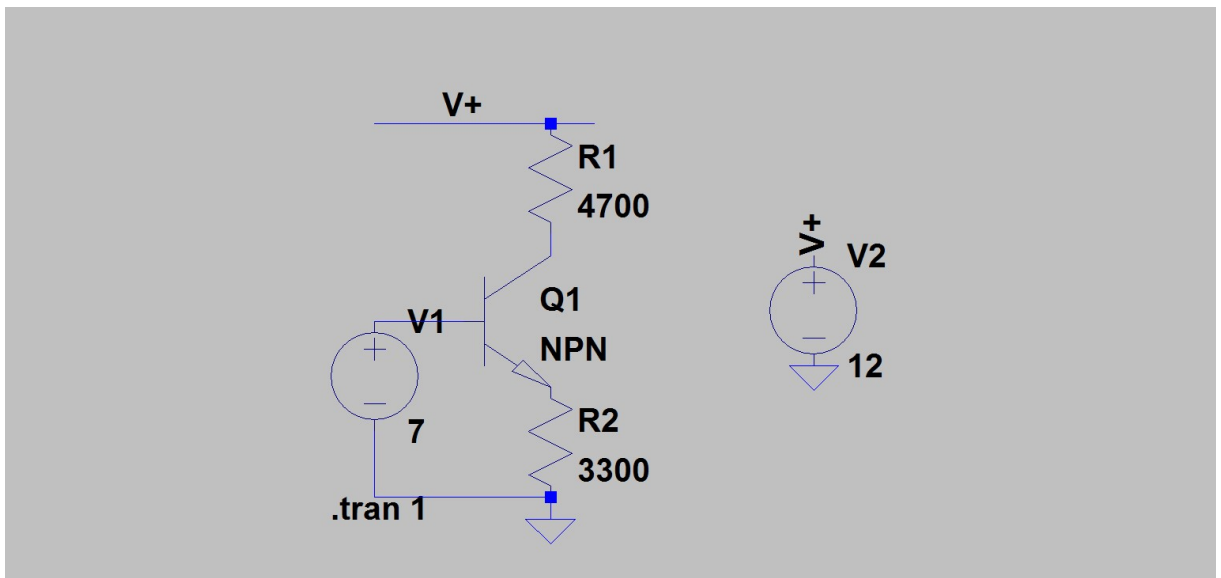
7. Describe your experiences from the planning and execution. What are the advantages? Is the method to categorize knowledge beneficial for you? What kind of support do you prefer from the instructor?

The survey

All the students (18) that failed the exam were invited to participate, with five signing up. Two more asked if they could take part in the process, motivated by lacking in understanding of the content. So in total there were seven students that took part in the mini course offered. Since it was done in the middle of the semester, and coincided with the first exam period it was a bit tricky to find time for the class activities offered (and a reason why so few participated). The content was presented as three short online lectures and an extra problem of a more complex nature, normally a problem for the highest grade on the exam. Each lecture included a PowerPoint presentation including tasks suggested to be investigated with a simulator for circuits. They were encouraged to write down their experiences and questions that arose in the process. These questions were then the main ingredient of the seminars offered.

Results from the test

The test was graded as if it was an exam. The level for the different grades are: U: <50%; 3: $\geq$ 50%; 4: $\geq$ 67%; 5: $\geq$ 83%

Table 3 - The results and grading

Student	1	2	3	4	5	6	7
Grade on exam	U	4	U	U	3	U	U
Test Q 1-2	30%	100	88	25	75	25	100
Test Q 3-6	60%	100	87	60	87	33	100
Grade on test	3	5	5	3	5	U	5

Evaluation of the test results and their experience from the planning and learning

Table 4 – Results and evaluation of the test and their previous grade on exam

Student Question	1	2	3	4	5	6	7
1	PE, CE	C	C	PE, CE	mCaE	PE, CE	C
2	NA	C	mCaE	PE	CE	MCE, MPE	C
3	CE	C	C	MCE	C	CE	C
4	mCE	C	C	mCE	C	MCE. mPE	C
5	C	C	C	C	C	C	C
6	CE	C	mCE	CE	mCE	CE, PE	C

Code: Correct (C), Calculation error (CaE), Procedural error (PE), Conceptual error (CE), No answer (NA), Minor (m), Major (M)

Table 5 - Reflections handed in with the test

Student	Written reflections on the content and planning
1	Really good way of learning! Fancy facts, procedures and concepts. Appreciated the simulations proposed. Did not simulate the last of three parts, claims that is why he missed out on the test. The simulations give aha-experiences and are highly recommended.
2	It was quite time consuming but gave a more direct understanding. Proposes that files are included with the circuits examined to save time. The facts, procedure and concepts got lost in the online lectures and should be emphasized more clearly. Misses a clear burden in the content. Believes in the activation of simulations while watching. Maybe a problem to solve should conclude every film.
3	The material is good but maybe a bit dangerous because of the dependence on the simulation demand. Had trouble with the simulation that did not work properly at first. The instruction to simulate during online lecture is a really good idea. Gave immediate confirmation of the concepts presented. Gave permanent points as basis and from there drew conclusions to discuss with the teacher.
4	Appreciates the small format so everyone can ask the teacher. Watched the lectures without doing the problems and simulations suggested. Tried to solve two problems before the test. A wake up call was that all I needed was Ohms law and KI and II.
5	Relationship I_B/I_C central – good. Explaining saturation/cut-off central – good: Gave an understanding for the working point diagram. Calculations vs. simulations: really good. It is good to introduce really tough theoretical questions: when ? turn up: `Why?´, `Explain´: → feedback. Laboratory work continuously would be greatly beneficial in the context of theory/arithmetic skills. Discussions: give room for discussions – good but perhaps hard in the traditional lecture hall. It is helpful to start with `facts´; feels easier to establish new facts. Thinks there is a point connecting the discussions of assumptions; tie facts to thumb rules with understanding. What happens if we do it in another way? Try other values? I.e. you just don't adapt but can make assumptions and relate to experience/understanding.
6	Likes the method in simulating at the same time as listen to the lecture. It would benefit from having a ready-made circuit for simulation to save time. Mentions that the more senses involved the better.
7	Likes the concept of layers of facts and procedures: You can immediately examine the facts with a simulation. `Hands on´ is good for learning. The discussions we had were great help. I need them and in small groups. Great thanks!

Table 6 - Interviews after the grading of the test

Student	Interview
1	Participated in the gathering without studying for it. Worked with the content the day before the test for 5-6 hours. Had problems at first because of not working simulator. Got stuck on the test on the first two problems. Explains his problems with KI and II with the three teachers had three different ways to use KI and II in the course.
2	Did all the homework before the first gathering. Did not need to write down any questions since he understood everything.
3	Worked for three hours on Sunday and performed the last assignment the next day before the first gathering. The planning promotes understanding: really good!
4	Worked with the content for approximately three hours. Felt some pressure from other exams and a vacation trip over the Easter.
5	Did the homework. He did not write his questions on the occasion. Choose to discuss it on the live lecture instead. He uses the simulator quite often to confirm the theory. Time spent was 2-3 h before the gathering and one hour before the test.
6	Worked with student 7. Video 1+2: 3h, Video 3: 1h, and did not do the extra assignment. I looked on the lectures again before the test and tested some different values of the components in the circuits.
7	See student 6.

Summary: Although some experienced that the emphasizing of facts, procedures and concepts got lost in some steps, the coin seems to have dropped. The combination of theory versus simulations worked well; which of course came as no surprise (references mentioned above). Several of the students discussed the content in *understanding* the concept. Most of the students benefitted from working actively with the content. The best outcome was that a student failing the both previous exams aced the test and that all but one "passed".

Conclusions

Since the study mainly focuses on students failing the exam the question is whether a new planning can help the students that struggle to find enough motivation to study hard enough. Experience shows great difficulty attending content and learning goals high up in the taxonomy. Since all learning is relative to the experience and gained knowledge, great care for the individual's status pays off.

Students understand knowledge presented as facts, procedures and concepts and can relate to that. It gives them another input for understanding. Since it is only a case study you

cannot draw any far-reached inferences on the benefits of the top-down perspective, but for a further study the impact should be emphasized. It is a key ingredient in many modern textbooks as well as in student-centered approaches like PBL and CDIO in higher education. The interviews as well as the test result clearly show a deeper understanding for the content; the concepts are clear and they use the right procedures. For those who do not *understand* and *apply* the concepts scarcities in their prior knowledge is evident. However, the procedure at hand they start with is correctly used so the planning clearly triggers more than just remembering, even though the concept is not understood completely.

Therefore the study implies that more complex learning can be accomplished using only the *understand* and *apply* of the cognitive levels in the taxonomy. The teaching of more complex learning outcomes can be planned in instructions of small steps showing clearly that only known facts are used combined with simulations to discover new facts of knowledge usable for new learning. It makes the concepts more clear when there are fewer procedures to be remembered.

Problems occur when students reach the workpoint diagram. It is clear that two of the textbooks diverge from the alleged top-down approach in this section. The survey indicates that the top-down perspective should be considered to promote a clearer focus on the concepts to be learned.

It is possible to create an understandable learning environment using the cognitive levels of understand and apply in the taxonomy. One of the advantages is that it is of less importance whether the knowledge is procedural or conceptual and the focus on the concepts is not diminished from remembering procedures. Lack of necessary skills prohibits the student to *understand* and *apply* the concepts and procedures.

Is there an issue that the teacher is the researcher? Action research on your own practice is not problem-free. In this case it is probably of less risk that students act nice since

they have already finished the course and their rest exams are anonymous. So the main reason for attending should be learning for their own sake.

Further studies

Establish the necessary skills for the learning outcomes to be gained in a regular course and make sure the students understand the importance of the assumed knowledge. Break down the learning goals in understandable and applicable knowledge and let the students work with simulators to reach the learning goals. Suggest verification of the knowledge parallel in the laboratory. Examine the students' approach to problems in the exam according to conceptual and procedural skills compared to the outcome.

The working material consists of online lectures working with an electronic circuit simulator. In the prolongation this can be a way to present online courses for Universities for distance students. The campus time with the teacher gets lost, but online forum chats and quizzes can assist the students. Questions and summaries exposed for the whole groups can be recorded and later published online. It is not a bold statement that IT appliances soon will include active whiteboards producing slides which of course are suitable for distance students as well, if the perspective is to sum things up or reflect issues during learning of new content, for example as the method in this paper suggests.

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Chapter 10 - Summing up

The study started as an evaluation of a teaching method based on student active methods concerning the students' development of conceptual understanding, in a perspective of the dependent variables of motivation and self-efficacy. Since learning is experiential and unpredictable, the outcome has turned more against motivation and engagement, and a development through the use of the taxonomy presented by Andersen et al (2001). There were four categories of students who were crystallized, and the main focus become on the two that struggled to pass the courses. The somewhat naive goal to reach an optimal teaching structure was later replaced by a more detailed approach to understand and apply the concepts to be learned in a mathematically demanded course in analogue electronics. The results are really promising since they imply that more students can learn the concepts normally forgotten in the process of studying procedures (algorithms) for the exam, most often a guarantee to failure and surface learning. A large problem is the culture and trust in that listening and reviewed solutions on problems provides knowledge. No matter how inspiring you are as a lecturer the student still has to do the job to learn the content and its use. Therefore, you as an instructor must seek for how to help the students to understand how to learn and process the content. Another key point is to make clear what is needed to learn the concepts: If the students lack in understanding of the necessary facts required for learning new concepts and procedures, they are more likely destined to fail regardless of their effort.

There are lots to learn in teaching in higher education. Relations, for instance, play an important role. So the anonymous chalk and talk-lectures and lessons are an effective motivation and engagement killer. The importance to know the students and their prior knowledge are crucial for making the instructions possible to follow more than in a remembering procedural way. Preparing the students for the time in the classroom supports the possibilities to open up discussions, and is further a powerful instrument for the students to return to for repetition. This can also be used to create a more coherent understanding for what is needed to know to learn and master the next content. It is difficult to predict how the students work to their best; for many the group work is beneficial, but can also be a deceiving trap just to accept and promote memorizing of solutions of more complex problems. Even simpler tasks can be neglected since someone found out a solution

and they all accepted it non-critically. Therefore possibilities to grade your knowledge shall be offered, both at fundamentals as well as on more complex problems and tasks, i.e. course aims. There is of course no optimal instruction to all students, even in one isolated course. All learning is related to a context and the participants and therefore the instruction needs to be considered and updated regularly. The more you engage in the individual's development the better the process of learning goes and the motivation and engagement rises. You can never expect students to become more excited than you are. This is often the biggest hurdle to pass to get them going from the facts and experience they earned. This is my recommendation on how you should approach your students:

Carefully evaluate the course content. Identify the mains of the curriculum and present them and its use before investigating and exploring them further. Establish what is needed to understand the concepts to be learned they already should know and make them aware of this. Create a working scheme for the students to reach the learning outcomes. If possible, use the understand and apply verbs of the taxonomy to learn new facts, concepts and procedures and give the students problems to solve and investigate to understand and apply what already is known. In preparation the students can get micro lectures online that:

1. *Demonstrates new facts and simple procedures, and*
2. *Relates them to prior knowledge.*

This gives you as a lecturer a first input on what is understandable and what is more complex. Use the time in the classroom for students working with instructions based on understand and apply. You will then have the opportunity to get to know them individually at the same time they are working and also be available for questions. Your relation with each student is a powerful tool for the students to be motivated and engaged and a big help for them to become self-regulated learners. Having them work on the content facilitated by you creates a direct input to a summary on exactly what comes up during practice.

If focus on the University is on research, i.e. the interests for the seniors are at seeking grants, publishing, hiring new staff, preferably PhD students, it is natural that the education comes second, third or even fourth on the agenda, or is done with your left hand so to speak. That makes the culture of instruction indefinite, which probably creates lots of more or less isolated islands of programs depending at best on the students' luck to get devoted

teachers despite the demands to succeed in research. A first step to start building a culture of instruction could be to set the bar right from the start. It is obvious that students cannot really know what is waiting for them, and probably many of them should seek other options for studying and career. Offering all new students a summer camp before the first semester to set the tone, for example, the engineering programs, will help them to understand what they should know, and what to study and how and give clear examples of the complexity of the content. This should help the students to get an idea if this is something for them. If they do not have the right prior knowledge or not have the understanding on what engineers actually have to learn, they most certainly are better of knowing that as early as possible. This will also help the structure of the curriculum and the planning of the courses: Clarity on what is necessary to know and what to learn provides for an improved understanding of the planning and content of courses, and the instructor follows their contribution to the program better.

It becomes apparent when working from a top down-perspective on a course that this can of course work for the whole University in planning its teaching: From the faculty The Whole Purpose of giving selected programs shall be established and transparent. For the programs the learning outcomes have to be decided and what skills it shall give.

The skills provided from the program shall be expressed. There are two kinds: First, the more permanent skills that rarely change more than bits and pieces, and second, the skills that are circumstantial and changes with trends, public and political demands, research findings, labour market, local communities and so on.

The program than has to be filled with activities that nurture the wanted skills. The skills must be broken down into more precise learning outcomes. Which forums create these learning outcomes? Modelling, Projects, Courses, Themes, Knowledge of and from the labour market, experience from the industry sector, projects related to the industry, etc.

To choose the proper structure the following questions have to be asked: How do the students learn this best? What facilities are necessary (and desirable)? What kind of expertise is needed (desirable)? Which knowledge is needed to reach the learning outcomes?

From each learning module then the content has to be decided from the learning outcomes: What literature is available? Which kind of activity studying the content is the best? What is the easiest way to learn the essence of the content? How to obtain the thresholds to learning via its planning, etc.?

For each teaching staff (one teacher or more) the structure of the learning has to be carefully considered: If there is no plan for the students to reach the learning outcomes they could quite frankly just study on their own. Lecturing is the 18th and 19th century style of teaching and was forever disqualified as the most effective teaching method by the work of notables like Dewey, Lewin, Vygotsky, and Mary Parker Follett that introduced the learning philosophy that stimulates more senses than pure listening.

When applying research and other experiences on your practice you must be aware of the limitations and opportunities qualitative research provides. In trying new ideas it has to be filtered through your own experience. Of course you could adopt a system or approach in its full and experience from that, but it still needs to be processed in some sense. Kolb, based on Piaget, Lewin and Dewey, gives us a method for a constant development of our practice, but it is important to realize that one step forward is sometimes two or even three steps backwards. The evaluation process is crucial to benefit from your experiences and finding the right conclusions from your efforts and analysis is not always the case. So even if you are a true believer in an evaluation model like Kolb's it is still just a model of reality. It is useless unless you realize that on some point it is you who colours the process and you will go wrong so many times regardless if the methods in use are highly rated. This is what happens when humans interact with data and test results; even in quantitative inquiries. The wish for success and the ability to foreseen bad results prevents us sometimes to draw the "right" conclusions. We are only human, and all is relative to a huge amount of dependent and independent variables impossible to take into account in whatever survey you perform. If this was possible there would be a formula for teaching and learning and every teacher, instructor or student could reach their best at all times.

Teaching someone something can never happen: learning is always happening in the learner's brain so the term teacher is actually quite useless. This could seem like a small trifle, but it is actually a big threshold for the process of learning. What term is useful then?

The tutor and the instructor's role suit the purpose much better: In front of large groups, the instructor can deliver resolute and in general fruitful instructions on what to learn and ways reaching the knowledge intended. The tutor works with individuals and/or small groups on more precise interpretations and explanations for the student(s) to understand better and learn. Therefore the term teacher has no relation with the students, merely a coalition or assembly of those who are assigned to help the students getting the expected knowledge. Actually it is more complex than that: Many students do not even know what knowledge to learn and why. So the teaching staff goes beyond tutors and instructors to include all people involved in the planning of the program the students are attending. If you consider yourself as a teacher in higher education you miss the most important role of them all, namely the interaction with the students in the learning process. It is not along ago since the one school system developed as a more or less direct consequence from the fact that all children were allowed, and obliged, to attend education. Even until today the one school system dominates the scene around the world in most countries through primary schools even though we are quite aware that the one school system is a huge blunder (see Shernoff 2013 chapter 1) since it discourages adolescents' motivation to learn; many of them see the schools as institutions you are locked in and have no fun.

The teacher

Intrinsic motivation and learning from everyone's interest, experiences and prior knowledge are the best prerequisites for optimal learning. I will finish this review with some thoughts about why the scholar system is so different (and low-performing) from these simple facts discovered and discussed at least as early as by Dewey and contemporary psychologists and education scientists. You can see from the development on the McMaster model that the role of the tutor was a major issue and there was no clear consensus on how he/she best nurtures the process of self-directed learning, but lots of discussions and memorandum on philosophical considerations. The teacher's role and different approaches to teaching hold a defensible part of didactical and philosophical research, but seldom is the concept of the teacher discussed or investigated. It seems like most of the practitioners and the researchers consider the teacher as a person that is in direct contact with the students, preferably in a classroom environment. This becomes both the problem as well as one of the reasons for the theories of good learning and teaching to fail more or less in practice. The teacher is by

semantic completely useless in terms of learning: Never ever can you teach someone something; all learning comes with the individual recipient of the students. Thus, a teacher by tradition who is in contact with the students is dangerously close to a person that will pass on information and show his/hers way to find a solution on problems to them. Besides that the teacher is so much more. The concept of the teacher is everything from in what environment the learning takes place, what to study, intellectual environments, physical and mental aids, evaluation and testing of gained knowledge, adaption to students as individuals and groups from a social/experiential/knowledge background, and the whole purpose for offering education. The minute you decide to teach someone something and get organized the teaching begins. Every part of the activity from there on is a part of the teaching. Therefore nothing can be excluded in the process of teaching without losing some valuable input to the process of learning. This calls for a major revision and, in numerous facilities of pedagogical institutions, a need for a complete new outset of the education offered, starting with a definition of and a purpose for the whole. Experience tells us that it is probably an impossible task to please every student in a learning community, but it should be fairly easy to establish communities, which pay attention to every single student in the program at hand, and act from there with the resources available. Unless intrinsic motivation is nurtured, and learning outcomes are developed from everyone the work of the teacher is simply not yet done. So the informer in the classroom may in some cases play an important role for the outcome of the studies, but that is based on the assumption that the teacher is a person in a classroom, which for obvious reasons is necessary for the learning process. Simply state that it is what is learned that matters in the classroom, not what is taught, is a start of a progressive and useful process.

A model from the findings of this thesis for the course coordinator as an instructor

Although there are no such things as a superior teaching model, you can present what is best at this particular time based upon your knowledge and experience. In the engineering education perspective where mathematics and physics models are used to explain phenomena, the following approach is the result from the study:

Show the Whole in a proper context. The whole can be an entire course, but more importantly, all components that become the Whole shall also be described as a whole in a proper context.

The function within the whole is described from previous knowledge and known facts. If the presented content needs new facts they have to be highlighted. This is not as easy as it seems since you have to realize what the necessary prior knowledge is.

Point out known facts for the concept and explain its function in the right context.

New concepts and procedures have to be understood and applied.

Give instructions on how to work with the procedures and concepts to master the new knowledge. Be particularly careful with pointing out what the new knowledge shall bring.

Demonstrate applications/use/benefits of the new understanding

The applications can be iterated with new instructions to reach further knowledge and understanding based on known facts.

Pay extra attention that the concepts and procedures are understood and its use: This can now be referred to and considered as facts in learning new concepts and procedures.

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Appendix

Icebreaker: Hur har du upplevt kursen och dess upplägg?

Upplägg

Använde du dig av Scalable-föreläsningarna?

Vad upplever du är den största skillnaden mellan detta upplägg och tidigare kurser?

Upplever du en förbättring i din inlärning och det du lärt dig genom upplägget? Har du lärt dig mer i denna kurs? I så fall varför? (Har du lärt dig mer pga. upplägget?)

Är upplägget bra för din inlärning?

De olika undervisningsmomenten: Värdera dessa! Scalable – fl/lektion – eget arbete med handledare

Upplever du att kursen/föreläsningen blir mer kommunikativ med förberedande föreläsning som grund?

Införa veckolaborationer, först med grundläggande uppgifter och sedan mer komplexa?

Inlärning

Hur värderar du dina egna kunskaper i ämnet?

Hur känner du att du utvecklats när det gäller helhetskunskapen inom ämnet? Har du utvecklat din grundläggande förståelse för el och elektronik?

Motivation – self-efficacy

Vad ändrades för dig under kursen? Blev du mer motiverad, fick bättre självförtroende, pluggade mer, fick större koll på vad som krävs för att du skall lära dig? (Här skall jag särskilt fokusera på de som pluggade mindre, som inte klarade av ansvaret att plugga på egen hand) Hur ser utvecklingskurvan ut för dem avseende motivation och självinsikt om deras vidare utbildning?

Har du fått bättre kontroll på vad du behöver kunna som elektronikingenjör? Är du medvetandegjord angående vilka kunskaper du bör bära med dig?

Hur mycket tid lägger du på dina studier per vecka? Hur mycket tror du att du skulle behöva lägga? Varför lägger du inte den tiden?

Vad anser du är de viktigaste skälen till att du går kursen?

Vad anser du skulle vara den mest motiverande faktoren att jobba hårt på en kurs?

Hur har det fungerat att arbeta i grupp? Finns det moment som fungerat bättre/sämre? Hur effektivt har det varit med grupparbete? Finns det moment där gruppen hindrar dig? Hur upplever du engagemanget från dina gruppmedlemmar? Är det en fördel att ha jobbat i grupperna när ni går in i gruppfasen?

Gruppen: Hur upplever du att gruppen bidrar till din inlärning? Hur effektivt är det att arbeta i grupp?

#1:   Did not take the first exam and failed the 2nd.

- Did not keep up in the first part, lost it after ~4 weeks

- Checked out only a few of the web lectures, but points out the importance of being prepared for the lecture

- Loses motivation when the lecture lacks in context

- Gave priority to another course and succeeded there

- Easier to follow at a lecture in mathematics

- Experienced the course ambiguous

- Prefers practical electronics where he can compare how it works

- Wanted smaller groups and needs a strong leader that guides him. Some in his group takes control how they shall work and the rest becomes assistants.

My comment: A spoiled youngster that haven't understood it's up to him to perform. Used to not doing much and still get bye. Lives with a secondary school mentality.

#2:   Failed first exam and got a 3 on the 2nd

- web lectures are really good, it's much easier to take part of the live lecture which he hasn't experienced yet.

- The lectures was very pedagogical and good

- Damn fun with group work. A bit different in the classroom when it's divided but really fun

- Learns more in group work, gets inspired. Encourages him to be in phase with the group, be able to discuss and analyse together and come up with the solutions

- Appreciated the conceptual approach of the lectures

- The ability to learn has definitely increased.

- Most useful course so far

- Started programming microcomputers on the side and designing his own projects

- His motivation has gone up and down. Claims that compulsory labs NOT would have inspired him more. Voluntary labs enough

- Best taking the course: Better hold of what the engineer supposed to know and what it takes to be one

- Most motivate: The benefits that comes along with hard work (nyttan I efterhand)

- Been working really hard at the first part.

#3:   Strong 3 on the first, failed the 2nd

- The first part was mostly about calculate, the understanding for the whole came afterwards

- The lectures were clear, i.e. spot on, great.

- Many teachers lead all the teaching; much better to sit together with the group and try to solve problems. Your confidence increases when you succeed solving a problem

- I'm a keen calculator of electronic problems but lack the understanding for the whole.

- Works less than 40 h/week except during cramming (tentaplugg)

- In the project I felt great pressure to succeed, it was hard for me to find motivation. The only reason for me to show up is because I must, can't leave the other group members behind.

- The biggest motivator is to figure out how to solve problems

#4:   failed both exam

- Having difficulties with the math. Liked that it was a lot of projects

- Mostly practical, hard to learn theoretical; and learn if he has to read

- Needs deadlines

- Very hard to catch on if he's not prepared. Needed to study the book (except for taking part of the web lectures)

- Lost grip because of laziness. Gets tired as soon as he starts to work with the problems. Should have taken a longer break after secondary school

- Think it was good communication on the lectures

- Learned a lot during projects, not so much of the first part. Thinks analogue electronics is tricky.

- Has none or slim grip of what it means being an engineer in electronics

- The group: Really clever group members can't solve any problems before the others. Is more of an assistant because he had a lot of absence (he claims) in the beginning of the projects.

- Although he's not the most active he thinks he understand the most of the work they've done

#5:   Failed first exam (11) and had a strong 3 on the 2nd

- Really good course; If you compare with other courses that includes circuits and make calculations on them, they lack understanding on what's happening in practical.

- theoretical, good at math

- Experienced the first part as massive at the start. Was too lazy. Started studying way too late.

- Has a goal to study as little as possible

- The token fell down during the first project, needs to work in practical to see what's going on

- It was an advantage to check out the web lectures before class, but no disaster if you forgot.

- Did barely work at all in his own time.

- When he started to see the practical use of the content it changed for him

- He learns a lot more with this strategy of working.

- The lectures became more communicative with the more process based teaching

- The courses in mathematics has made him lazy

- Experiences that he has good knowledge in what is the demand for an engineer

- Motivator: Have fun! To have a goal in sight

- His group was as good as any.

- Did not work within his group before going into the first project in the first part

- Was too lazy to work with the weekly problems handed out

- Took responsibility for the project in the first part and contributed despite lack of basic skills in transistors. It was really all but having control of Ohms law and other

basic skills already learned in previous courses despite the fact that it included new components.

#6:   Failed the first and had a 3 on the 2nd

- Liked the project phase, although the groups were to large; some in his group were much smarter than him, which makes him not come up with solutions. Grouping of four recommended.

- Puts in 20 h/week and gave priority to another course in the first part. Checked out the web lectures in the beginning but gave that up soon.

- Knows he has to study more

- Completed all courses in the 1st year but one. Studied just as little in the 1st year.

- Claims he knows some in electronics but not the first part

#7:   5 on the first part and a strong 4 on the 2nd

- The 2nd part is completely different from before

- Really good course, super satisfied

- Links everything from the 1st year together. Aha-experience

- Best course so far

- Motivation is given to be your own teacher.

- You must motivate yourself, students need that to be able to learn.

- You encourages us to start our own projects and discuss them with you. If your classmates aren't interested in exploring new ideas there is normally no one to discuss the problems with.

- Had to put down a lot more work in the first part. It demands a higher level of maturity, which makes the process to digest it longer, but it makes you eager to learn more. GREAT FUN!

- Realized during the course that the foundation was laid and now the token fell down and I realize there is so much more to learn

- Works in my spare time with micro controllers and IR-transmitters and receivers.

- Has a whole pile of small projects at home just waiting to be processed, but right now not enough time.

- The web lectures doesn't give much, but the lecturing does.

- Very open format for the lectures makes it a good place to ask all your questions. Good communication. No need for taking notes.

- The biggest difference was that your lecture didn't cover the fundamentals; it was necessary to come prepared. That gives me more even if I didn't understand anything on a lecture, it somehow worked out later on

- The tutoring parts were better than teacher led lessons

- The mini project on HiFi gave enormously. There should be an option to finish it before the exam.

- Works 40 h/week and nothing at home

- The project work on your own makes you work harder, which is also the best motivator

- Sees no problem with different ambition level between the group members

- Useful to help other members in the group when they're having difiiculties

#8:   Failed miserably on the first part and a 3 on the 2nd

- Well organized, everything we do has a meaning

- The project work more fun than the theoretical part

- The HiFi was fun

- First part difficult: Good to have web lectures, made you aware of what to know in advance

- Had problem studying before the exam, can't tell why

- Skipped the group work in the weeks and tried on his own. He couldn't cope with all the talking in the group during class. Needs to read by himself first. Works on his own mostly.

- Puts in 50 h/week but the work in school less effective

- Set the priority for another course in mechanics

- Got lost when introducing the model for expressing the transfer function with a Bode plot. Lost motivation then and focused more on the course in mechanics. As the token fell down it was too late to catch up.

- Likes maths

- It has become easier to learn electronics during course. Has developed an understanding for the components which makes it easier to make calculations on circuits there in.

- The biggest motivation is to finish a course and come one step closer to graduation

- Disappointed on the group's performance, it's up to them if they like to learn.

#9:   Failed the first part (10,5) and had a 4 on the 2nd

- Really good with the project in the 2nd part

- The course should be divided into a digital and an analogue part (which it is?!?)

- Worked really hard the last ten days for the first exam. Turned the day upside down and wasn't at his best on the exam day. Focused somewhat on wrong parts of the textbook.

- Sat almost every facilitated class and worked in his group

- Studied less in the first year, never studied so hard as he did this semester

- The web lectures was good

- Found web lectures on the 2nd part on Youtube

- Isn't too worried about missing out on the first exam. Feel he knows a lot.

- Conscientious (plikttrogen)! Prefers projects before studying on his own

- Fun courses make it easier to "waste" time studying. For example the mechanics course felt harder to learn because of the feeling of lack of relevance

- The group itself was very motivating. It takes a little longer to get to the solutions in a group, but that maybe how it shall be?

#10:   Failed first part and earned a 5 on the 2nd

- Often in the role of helping the other members of the group

- Definitely the most fun course yet: the mix between practice and theory; problem solving!

- Main difference: Not a lot of lectures ending with a written exam

- Having difficulties counting. Doesn't enjoy it. Solved some of the problems in the textbook, not all of them.

- Checked out the web lectures a couple of times. Good preparation

- Felt the transistors to be tricky

- Benefitted from the theoretical part in the elevator project

- 35-40 h/week, 60 h/week in the project

- Much more fun working in a group, the group members complement each other well

- His knowledge has developed during course

#11: Failed in all parts of the course – hasn't got the capacity to learn.

- The groups were too big, to many cooks for a soup

- Fewer members in the group – larger engagement

- Worked together before the project start

#12:   A 3 on the 1st part and a 4 on the 2nd

- People in the class that are motivated makes it easy to latch on. Is not the driving force of his environment

- The first part felt traditional

- Works office hours which varies some. Never at home. Tired in the mornings makes his effort less than 40 h/week

- The web lectures gives you something very concrete to do before the class. You know it takes no longer than 15 minutes

- Worked as well to watch the web lecture afterwards

- The teaching was a lot freer. The lecturer is extremely important, important to be able to ask questions. The structure was really good; Lots of exercises but extremely well structured

- The open format and attitude opened up for communication during lectures

- The honesty at the start: If you do this and that you will succeed is important and that vouches for (borgar) completing the course

- The facilitation lessons was very good

- A question mark for the group size. Afraid that many can't work in groups as large as eight participants

- In the project phase we worked separately at first and the gathered and chose the best solution. Here there rose a problem: The ones that hadn't come up with the solution were left a little behind because of problems following the thought behind the solution. Its solution was pairings where the solution was discussed.

- The group contained no leader

- Fixed frames important to me; need to know what shall be done. It's easy to put things on hold. If I'd been in another group I'm not so sure it would have turned out this well for me.

- Learned how to read data sheets of components

- Gained insight in how I better learn. There is a big difference between being pilotage through secondary school and have to catch up and learns things on your own. The transition to actually study.

- The motivation for working really hard is a whip. Also when a problem becomes solvable it starts to be fun and makes it a lot easier to put down the necessary effort in it.

- My role in the group is being fun and friendly and come up with new angles how to tackle the problems. I'm more practical than the others.

#13:   Did not take the first exam and had a 5 on the 2nd

- Big motivation problems in the first part which led to bad presence. Missed a couple of lectures and was left behind. Caught up eventually.

- Puts in 5-6 h/day plus weekends. Used to play a lot of computer games but has realised that he has to cut down on that time in favour for studying

- Think the web lectures is good but think they moves on to fast; he's not much for pausing and consider what he didn't understand. Thinks though it's much easier to understand something he's already heard even though he didn't understand it the first time.

- Has no comments on how he experiences his own learning

- Great group!

#14:   Scored a 4 on both exams

- Useful to connecting the circuits they worked with. Project is a great learning process. Finds the group vital.

- Some of the group members are much smarter so he doesn't contribute so much to the suggested solutions. Would have been fun to be the one that comes up with the solutions, but that's not the case. No one has complained but claims he hasn't come up with any solution in the projects

- Not sure if the group really want him there.

- Fancied the web lectures but would have preferred to have solutions to the tests connected to the lectures

- Thought that maybe it helped the structure working with defined topics each week and learn them thoroughly (grundligt)

- Unaware of his learning ability

- Working in groups favour the learning process

- The planning gave him better grip of the whole.

- He sees the correlation between the web lectures and understanding the concepts of the lectures. Questions are raised, the right Q seems to be thrown, more relevant Q are raised.

- Has no real idea about his own understanding in electronics

- It's possible that the planning has increased his learning process

- Can't study at home, has to go to school to be able to focus. The group has nothing to do with his focus.

- 40-45 h/week. Tougher course means he's to put in more effort and time

- Motivator: Completing the course

- It's possible group work can be disturbing for some (because of the volume in the hall)

#15:   Failed first exam (9,5) and a 3 on the 2nd

- The analogue part was to much – could not decide what to study

- If you're in the lab working with a project making a circuit you can sit for 6 hours, when solving problems tired after 1 h and them the concentration is down to 50 %.

- Spent more than 50 h/week and still didn't pass. In the beginning it was more like 30 h/week though. Would have benefitted from having whips on him like two smaller exams, or something that forced him to start studying hard right away.

- He didn't get what many others did that what to be done was quite clear.

- My group seem to work just as much as I did and still they got 5:s and I failed.

- When you come up with an solution you get a kick

- The web lectures were awesome; looked at them several times (each one)

- The best education is a project in groups, but you learn more by yourself

#16: Failed 1st exam miserably, got a 3 on the 2nd

- Lots of stress

- The web lectures were good

- Puts in to less time; 8 h/day is too much, gets tired and goes home where he doesn't study at all.

#17: Failed both exams.

- Hasn't been that active, the project changed it

- Didn't study the 1st part at all. I'm very lazy

- Didn't have to study in the 1st year and got all the courses done except for one, a math course which was deadly boring

- It's fun when you get it!

#18: failed the 1st (5,5) and a 3 on the 2nd

- Feels under the other group members in capacity

- Had a reaaly lousy 1st period with a break up with his girlfriend

- Having great difficulties to follow lectures in common. Totally lost if he takes notes.

- Very fond of the composition with web lectures, live lectures and time for problem solving under supervision. Used the web lectures for repetition.

#19: didn't take part in the 1st examn and had a 3 on the 2nd

- Feeling great difficulty in taking responsibility on her own

- The web lectures were good for following the live lectures and then go back to the web lecture for understanding

- Followed the education each turn and worked for 40h/week

- I'm a slow learner but I've learned a lot in comparison with before

- Think it's easier to ask questions when you've prepared for the lecture

- Needs to see it on paper to know what to do.

- The practical work makes you see how it works for real.

- Group work functions well as it becomes like a whip to actually sit down and work. Easy to do something else if no one is pushing you

- Motivator: To know that you really know something

- Prefers deadlines before the open format: "volunteerism is evil…"

- The group work was somewhat ineffective since all parts were made together in the big group.

- A change of group in the middle would probably have been beneficial for all

#20:   Failed the 1st exam (11,5) and scored a 4 on the 2nd

- Even though the facilitation was a lot you should have had an assistant in the project phase. I've had no problems getting all the answers I want but it's just a hunch

- A summing up after each project would be appreciated

- Even though you could get deadlines it's much better if the course coordinator sets them; Gives structure and frames for the work.

- Has got a very clear idea on the whole in electronics

- Has it relatively easy to learn new things

- Had like many others difficulties in starting to study hard

- The web lectures good for feedback

- Suffered some at the beginning but got the speed up after a couple of weeks.

- Thinks the planning had enough time to learn

- Motivator: When the task(s) are so interesting that you don't think that it's ailment (jobbigt). You get that this can be really fun to work with.

- The group has been divided with a core of four, and four others (other programme) that came and went some.

#21:   A 5 on both exams

Really good structure. It was good that the teaching was voluntary; you're able to make your own planning, Plan your work each week.

The web lectures was really good. I'm used to prepare for the lectures in previous courses and this way it was much less time consuming. The 10-15 minutes was enough to come well prepared.

The weekly structure worked well: The group work wasn't that effective so I sat by myself at home on nights and weekends instead.

Works about 50 h/week, 9 h/day and 5 hours in the weekends. Considering himself to be quite lazy.

There was a good mix of theory and practices, projects: I have learned quite a lot from this course actually.

My learning is what it was. I learn a lot from answering questions from my fellow students. I hope I've learned them properly ;-)

Motivator: Not sure what to expect but always work hard in order to learn. A good grade on the first part made me more motivated to fight hard on the 2nd.

The group work has been a little so and so in the projects. I've done most of the work but there has been lots of discussions and they are all nice guys so… One of them often came up with creative ideas I'd work with and develop.

#22:   Failed the 1st (8,5) and had a 3 on the 2nd

- In general troubleshooting is missing. Your structure benefits precisely this, which also inspired me to work on my own at home (with projects), gained confidence to try things by myself.

- The previous courses has mostly been strictly theoretical, the practical work have been out of the context with no clear purpose.

- The first project wasn't as rewarding as the other because of the complexity and the fact that we got stuck on so many parts, and also it didn't feel necessary to design something that in the end can be replaced by one component

- I've had an insight in what the work will consist of, both hard- and software.

- The web lectures are really good, but you should record all lectures and put online. I would have preferred longer introduction lectures because I'm not the brightest.

- On the facilitated lessons he worked with whatever came closest in the planning, assignments, tests, weekly problems and so on.

- Works six days a week: the sixth day is to catch up on what's been left behind. Don't mind that because he enjoys studying. Studies even more closer to exams.

- Has developed a satisfying understanding of the whole which shows in that he often has to explain for his fellow students and fancies that

- Extremely important to work with engaging projects

- A very diverse group in ability skills and the work has gone well.

- Two members were sacked

- Thinks that struggling students put much more effort in documenting all that's taught.

- Thinks that trying to complete the course without the sharing of the workload and difficulties in a group would be much harder

#23:   3 on both parts

- Really good! Good to be able to set your own bar. I myself have been bad in taken all the chances, but still you get all the ways and means to learn. In the first part for example you were available for facilitation the whole time.

- The quizzes were no good, too hard to answer

- Web lecture with a brief summing up to begin with was good

- Every part is on your own responsibility, no deadlines. Big + on that!

- The learning process hasn't changed, but better view off the whole.

- Good with larger projects

- I'm very busy in my private life so I make use of all the teaching given.

- You can ask questions when you're prepared, gives you security too know what is going to be lectured.

- Works 35-40 h/week. Always present at beight in the morning but leaves early sometimes

- I know what I can and where to collect the knowledge, that's what's important

- This course binds together what was taught in the earlier courses

- Enjoys the theoretical part best, projects with trouble shooting is not so good.

- Motivator: I will pass the exam! Nu I know this!

- Even if you work on your own it's good to have the group and ask fellow students in case there is no immediate contact with the teacher. Felt bad about kicking out two of the members

#24: Just missed out on the first exam and got a 3 on the 2nd

I alla andra kurser så har lärarna gjort allt för att vi skall klara kursen. De har försökt gjort allt så enkelt som möjligt för oss. På labbarna behöver vi bara fylla i svar på frågorna, instruktionerna är väldigt tydliga, man vet alltid vad man skall göra. På lektionerna så löser de alla uppgifter vi har och tentan kommer bara på det som gåtts igenom på föreläsningarna. I det här projektet finns det inga instruktioner, allt vi fått veta är att vi skall bygga en hiss. *–Men det finns en skriftlig instruktion som mejlats ut.* Du berättade den muntligt för oss men jag skulle vilja ha den skriftligen. *Den finns skriftligt men jag medger att den är väldigt öppen eftersom jag inte vill begränsa er och alla ni vet ju hur en hiss fungerar.* Jag tycker att det skall finnas tydliga skriftliga instruktioner. Hur skall jag lära mig det här, jag har kommit efter. Vad skall jag läsa i boken? Kan du tala om för mig hur jag skall plugga för att komma ikapp? Skall jag lösa bokens övningsuppgifter? Är dem bra?

- The analogue part best: Clear and distinct what you're supposed to do.

- The project part should have been more like the above

- Web lecture – lecture – lesson + facilitated problem solving +++

- Misses laboratory experiments that should give credits

- Works 6-7 h/day, obviously not enough

- Should have been one more teacher that can explain in another way.

- More learning parts, for example laboratory experiments

#25: Almost a 4 on the 1st, and a weak 4 on the 2nd

- The first part stands out: Really good with the weekly planning. I like to know what's gonna happen when I come to school.

- Previous courses hasn't been as well structured; almost fuzzy (flummigt)

- Would have wanted the same composition of the 2nd part which was completely new for me

- The planning improves my learning.

- The lectures pretty much like before although the followed lesson with basic problems was good.

- Although your lectures are good I did not experience any difference in communication during them

- I've learned a lot. The course ties together what we learned in the first year in a nice way.

- Has given a holistic understanding, THINKing ON YOUR OWN! Not just sit and abrade (nöta) solutions to problems

- The motivation was high during course

- 40-45 h/week, mostly in school 8-17

- Motivator: Fun, challenging and rewarding; shall give something for the future

- Had difficulties during project: never felt into it. The effectiveness can be inhibited if the group is too big.2 and 2 and 3 and 3 is optimal. Otherwise a very good way to study

- My performance has been better than I thought it would be

#26:   4 on both exams

- Likes the fact that I know all the names

- The first part was just studying without knowing what to use it for

- The 2nd part was too low

- The projects made the course diffuse; there is only one person that needs to come up with the solution

- At the start of the 2nd project everybody just sat there and did nothing so I had to go home, open the textbook and come up with a solution and then explain, explain and explain again.

- But at least I learned a lot

- The motivation level was so low that the question was not What can we do more rather than How can we finish it up with the least effort.

- The first part was very clear what to be done and what to know. Used the web lectures as a guide on what the lecture is about. That was better because otherwise it's easy to just copy the lecture notes and hope to understand somewhere along the way. Now I could keep up and understand what was being taught.

- The facilitating turns (pass) were good. Sadly their wasn't enough problems in the textbook.

#27:   5 on both parts

- First and for all the dividing up was good

- The web lectures were good to go back to, should have taken part of them more during teaching period

- Good with scheduled time for problem solving, and together with working in groups it was easier to structure the work, get all to engage in

- The 2nd part was confusing, no need for checking the schedule but even though it floated on

- I was lazy and didn't check the web lectures all the time. You get some extras. More questions arise in your head when prepared; easier to pop the question

- I'm learning more holistic with this structure

- This course have aroused interest and perspective what is possible

- The field trip and the guest lecturer were very good

- Gave a perspective in what to learn, I know that now

- 40 h/week, 8-17

- Motivator: Challenging and new

- In need for safe tutoring so I can exchange ideas a lot. It worked fine within the group

- The clarity is an advantage when there is group work; if it's scheduled you show up and work!

- Can't believe some of my classmates: leaving school in the middle of the day! Do they know already? It's really weird

- It's hard to write a report when you're eight. It becomes 1 or 2 that'll do the work

- The most important future for a teacher is not being an encyclopaedia, BUT to engage and find interesting angles and ideas coming from the students

- The more controlled project was easy to do in a larger group; it was much harder to do the larger freer project. Not so easy to come up with ideas, better to sit by yourself and ponder and figure out possible solutions

#28:   Failed the 1st part (9) and got a 3 on the 2nd

- Good course, my performance is because of laziness and bad discipline

- The projects lowered the motivation

- You could do without the web lectures; I had the necessary knowledge from the secondary school. On the lectures it's quite clear for me but when sitting by myself solving problems it becomes difficult.

- Cannot say what's good, but it was

- The facilitation gatherings were a good concept but it was too loud in the room so we sat elsewhere and worked part of the group: That worked well!

- Important for the learning was to sit down and connecting the circuits to see what really happened.

- Much easier to ask you for an answer than my previous teachers.

- I think I've learned how the textbook works, can go back to the web lectures and tests and that should work for preparation for the rest exam.

- The course focus has been on what to really use the components for. Previous courses has had no connection to the reality, here we can see that we make something that really do something (useful)

- I feel I can buy components and do the coupling and it'll work

- Used to group work during the whole of secondary school. You must let some things go when you're working in a group, else you spend hours on things you already know and then starts questioning it.

#29: 5 on the 1st and strong 4 on the 2nd

- The first part was smooth. You got out more of it; it didn't feel like the teaching was for 10 credits. But still the schedule held together.

- The last part was a bit unused; so much spare time for you but it worked out anyway. More scheduled time in forms of labs might have motivated one more?

- On the 2nd part it felt like you didn't amended the content in the same way, if it had been a regular written exam it would have been an incentive for working more. Now I'd already an idea on how to solve the project so I didn't listen as sharp as before although I was there. Maybe should have had some exercises on the automat?

- It's really good that you know all of us; you don't fall between two stools. You've been spoken to all of us!

- ***In a regular course you just put your head down and moves on, and the lessons turns up when they come***

- To be able to solve problems under facilitation every week creates continuity and structure; now I know what to study which makes it easier to really sit down and start working.

- The communication got better on the lecture because you know all of us (by name)

- The 1st part would have benefitted from having another (traditional) lecture

- The web lectures were very valuable for the live lecture

- The course have been fun which was motivating

- It's hard to motivate to do the necessary calculations when working in projects, more of a trial and error method was used. It would have been better to have some more exercises as a start of the project, perhaps a more specific solution path to follow.

- Have put in less work in this course, ~45 h/week

- To learn what's inside the IC the most important factor to take on the course.

- Motivator: The possibility to sit and work during school time

- The group itself created a pressure to perform

- Me and August was the pushers of the group which no one complained about

- I learn from teaching the others what I've come up with

- It's a great value in working in groups since I need a sounding board to discuss with, otherwise it would have taken more time to learn.

#30:   5 on both parts

- It has been really rewarding; in the first part you got to know what will happen. Really fun with the projects.

- The web lectures was very awarding. I missed one and and it became much harder to keep up. I'm not the type that asks questions.

- Could have changed the order so lecturing had been Mo/We only critics

- To put in labs on the weeks content a good idea. If it's scheduled it's more likely to be done than now when there was an option that was given.

- The group was excellent for getting answers to my questions

- I can't say I have great control of the content, but I understand the math behind it Don't understand how the transistors really work

- The guest lecture was really rewarding

#31:   No appearance on the 1st and a 3 on the 2nd

- The course felt relatively normal with assignments and lessons.

- Needs deadlines

- Started working too late. Participated on the lectures but left himself behind.

- Easy to follow on the blackboard but then at own problem solving it became too hard.

- Lacks in the fundamentals – needs reminders on the lecture

- Postpones everything until it's too late. The group work hard because the team members start going home early and the other follows

- Spends about 20 h/week on studying

- The biggest difference was the lack of deadlines

- Studying by looking at old exams; missed one course the 1st year because the exam didn't follow the template.

- The guest lecture plus the visit to Scania gave good insight

- Studies from internet, Youtube and so, instead of reading the textbook

- The whip is the best motivator

#32:   No appearance on the 1st and a 3 on the 2nd

- Good with top-down in the 1st part, easy to follow when you start broad and then on the depth: GOOD! It's like studying a pyramid, would work on for example math courses

- Followed the web lectures at first but became lazy in the end and forgot (?) to check the schedule. The web L was good because you got a hang of it right away and could follow the reasoning right away on the live lecture. Worked well to start solving problems after

- The conceptual part felt better. Really good for me! The group work lifted when Viktor arrived.

- My own discipline bad, the group lifts my motivation

- 15-20 h/week followed by a lot in the exam period: doesn't work to study like that. Neexds a change.

- Have some left from 1st year

- 75% failed exam last spring when the exam was outside the template.

- Projects and deadlines the biggest motivator

#33:   5 on both exams

- It feels like you learn in a whole different matter in projects. A good way if you're interested

- The 2nd part hard to learn by just reading and calculations

- The first part included lots of things in a short time. Really easy to know what to do thanks to the structure and the planning.

- The web lectures really good; checked them out just before the lecture

- Was a bit confused the first two weeks but from there on it was quite clear.

- The web lectures were good to watch again when studying for the exam

- We worked together in the group until I was done and then left for home. Liked working on scheduled hours

- Good for the discipline with a lot of scheduled time for your own problem solving. Can't understand why some don't use this time to come and work.

- I've developed the ability to think and plan for myself and make own stuff. In electronics something actually happens when you connects, and then you analyse what happened and change and see.

- Didn't need to study so hard on the first part

- My strategy is to work until I'm done with what I set up for the day and then I quit.

- Motivator: Fun with grades; usually don't need to motivate myself. Working in groups makes it much easier

- The groups should have been smaller in the projects

- In the grouping you can't say: I want to work with all the best, the others have to manage on your own. The followers isn't only on their behind but doesn't contribute with the solutions: They became annoyed when they didn't succeed.

#34:   Failed miserably on the 1st and 4 on the 2nd

- Essentially a good strategy, underestimated the 1st part

- The tests with the conceptual focus I didn't understand

- Used to study old exams and got by but here that didn't work; Got a sledgehammer here as well ☺

- Worked significantly harder on the 2nd part; 12-13 h/day, 5 h/day on the 1st part

- This course is more demanding than the courses in the 1st year

- It felt strange that I could follow as well as I did because of the complexity, could have been the web lecture preparing. The conceptual lecture more understandable

- The understanding for the whole progresses even though it's hard to understand the 1st parts textbook

- Know how I learn (tested it) and sticks by that

- Would have needed an alarm clock in the start despite the fact that it was clearly spoken that this course is tough. The repetition part is good but could be lifted out to a prep course sent out in advance.

#35:   Failed both parts

- The web lecturing really important. Good for repetition as well

- Really good course actually

- Electronics is new to me and will demand a great effort.

- Problem linking theoretical with practical use

- 40 h/week

#36: strong 4 on 1st part, 5 on 2nd

- One of the most reasonable courses so far. This is about what we shall know as an engineer

- It needs a test in the 2nd part; we learned things that can't be examined on q written exam but I didn't learn all of the content.

- The first part was really good.

- The weekly structure was really good, I missed one lecture and that time I couldn't follow the lecture as well as the others

- Worked really hard on the project phase. Lots of trouble shooting was both encouraging and frustrating at the same time.

#37: scored a 5 on both parts

- Extremely rewarding, tough but it's been really rewarding; much tougher than I thought

- Works extremely hard to get highest grade on all the courses. On many courses it feels like I'm wasting my time but this one was just rewarding

- The group worked very well. I imagine it's hard to work in a group where there is a lack of ambition.

- Lots of bright fellows spurs (driver fram) me

- At least 40 h/week. What else is there to do that's more important? Electronics must be the most important!

- The 1st part would have benefitted from been divided into two parts of exam.

- I like that you're not afraid of testing new ideas

- The web lectures are good. I always looked back on them and then tried to answer the tests. Then I get a view on what you expect me to learn.

- Think about setting two levels on the control questions.

#38:   A 4 on both exams

- Exciting highly intensive course. Finally we have started to do things that are related to the goals of the programme. Earlier it has been more diffuse what we studied.

- The course's outcome was good because now in the more complicated circuits I could see the connection between the content from the previous courses and use the learned methods on new components.

- The big difference was the weekly structure instead of just pushing new stuff from lecture to lecture, it became quite clear what was the purpose if each week. Earlier the content has felt overwhelming and therefor easy to lose track of the content to learn

- The level was even and good from week to week

- The scheduled time for your own work was a huge benefit

- The group work was good but often you sat two on two or three on three and worked with the problems.

- It was a clear advantage to check out the web lectures at breakfast to know what was going to be processed that day.

- It's easier to ask relevant questions when you're prepared

- The learning process has developed because now I can see what's happening and think more for myself what's going on if you introduce new components.

- The motivation became less and less during the first part because of the increased complexity. My discipline wasn't too good but it worked out anyway.

- The group was motivating me to show up and work

- The competitive spirit is the biggest motivator

- I try to participate in all the scheduled events. Studies nothing at home.

- 30 h/week, more on the project phase

#39:   a 4 on both exams

- Good structure with web lectures, but the live lectures went to fast for me so I had to fo home and sit and go through everything again step by step.

- Solving problems directly after the lecture was no problem

- Sitting at home solving problems by myself. Might have been more effective to be in school under facilitation but this is how I always done it.

- First course I had to use the textbooks

- The live lectures different from others: you freebase some which makes it hard to see the burden (röd tråd)

- It felt different and took some time to get used to the planning but probably a better way to learn.

- Feels confident in having control of the whole. Couldn't understand at first how I'd manage to learn this

- 1st year mostly repetition from the secondary school, this was the first course that required studying the textbook

- Felt an uphill during one part but when mastered that it gave me a boost. After that it felt like that a couple of times, always ended up with a boost.

- Max 40 h/week

- Really fun working with projects; Problems I know I can solve is the most motivating factor

- I solved most of the problems myself at home and then to school and explain them for my fellow students.

- I see myself as an inventor, despite the fact that I feel somewhat slow (to figure it out)

- Was the pusher of the group together with Lucas

#40:   failed miserably on the 1st and a 3 on the 2nd

- Gave priority to another course at first so not much effort in the 1st part

- After the exam I discovered the virtue of (förtjänsten av) the web lectures

- From having difficulty to follow on the lecture it became better on the 2nd part after preparing for them

- 8-10 h/day

- The structure is good but I failed to make use of the facilitation turns (pass)

- Should have benefitted from another lecture each week

- The motivation varies during the course; important to understand what's been taught, discuss with others, read the textbook to understand

- Despite you repeatedly said that you were here for us I didn't ask you when I was lost

#41:   Failed miserably on the 1st and a 3 on the 2nd

- When the going got tough I responded by gearing down instead of up. Having great difficulty to sit down start working.

- Didn't participate in the joint lessons under facilitation

- For motivation needs pressure from CSN and deadlines etc.

- Having difficulties on every part of the course, but the projects made it a little better

#42:   failed just on the 1st and a 4 on the 2nd

- Biggest course yet. Good structure with the group work. Careless mistakes mailed me miss the 1st exam

- The lectures were good, the work was "leave no man behind"

- During the semester I'm more than happy to work within a group, but closer to the exam I prefer to study by myself

- All material was handed out and the pre-requisites to pass the course. It's all up to yourself

- Participates on most teaching but during project course I skipped some in favour of another course work

- Works less than 40 h/week

- If you prepare for the lecture it's so much easier; it speaks for it selves.

- Like to look on the internet for help learning

- The group becomes important when the motivation drops, it's not just the lecturer that helps you.

#43:   Just (13) missed out on the 1st part and a 4 on the 2nd

- Super idea with the web lectures

- Very nice with own scheduled time for problem solving

- It was a lot of useful information and it's up to you to process it and not just a lot of lectures going on and on with lessons occasionally

- The studying for the exam failed because of bad discipline

- The weekly structure helped for motivation

- Fun with a course that was practical

- I have the overview of the content but the lack of discipline tripped me.

- No studying besides what's scheduled

- Have never needed to strain (anstränga) myself but realises now that the university requires some effort

- The group work is good for all parts. My group is a bit too fast for me

#44:   failed miserably on the 1st and a 4 on the 2nd

- Liked the structure with lecturing and then the opportunity to test it in practise

- Some of the assignments were unnecessary, to easy. Better to put in a calculation assignment early.

- The web lectures didn't help that much but you knew what was to be expected on the lecture

- Worked well to solve the problems on my own, much is out there on the internet

- The biggest difference is that there has been a plan for everything. Better prepared. Closing moments before going on to next, other courses has been more fuzzy, This has led to better learning

- It's hadr to be communicative during lectures; I still get all the help I need (afterwards)

- You have better contact with the whole group than what I'm used to

- You always takes time to answer the questions that's raised during class

- I'm better practical than theoretical

- 15-20 h/week besides teaching is more than enough

- The mini project very helpful for the 1st exam

- Feel much better in understanding the whole; simulations, designing PCB's, knowledge on components: Really satisfied actually!

- Sits a lot in the laboratory in the evenings and working.

- During the course it has been much more fun so the motivation has been rising all the time

- Important to have fun to be motivated; new stuff inspires.

- Changed groups during course and found me much better in the new group, everyone is so much nicer and more fun

- The projects were good and effective, it has taken a lot of time but even though it takes more time you learn a lot more

#45:   failed the 1st (10) and a 4 on the 2nd

- Good with projects; with all the respect for lectures it's in the laboratory you learn.

- Have had personal issues during the 1st part so no real structure in my effort there

- Have consider to take a break and work with something and regroup and come back more motivated

Talföljder – vilket är nästa tal i serien? Fyll i luckorna!

1. 3, 9, 27, 81, 243, ____

2. 3, 5, 9, 15, 23, ____

3. 7, 5, 12, 17, ____

4. 3, 4, 8, 17, 33, ____

5. 8, 11, 10, 9, 12, 7, ____

6. 2, 3, 5, 7, 11, ____ (Två möjliga svar, svara bägge!)

7. 27, 64, 125, 216, ____

8. 4, 2, 16, 5, 3, ____

9. 3, 5, 3, -3, -13, -27, -45, ____, ____

10. 1, 1, 1, 1, 2, 3, 6, 11, 23, ____

11. 0, 1, 2, 3, 6, 11, 20, 37, ____

12. 27, 82, 41, 124, 62, 31, 94, 47, 142, 71, 214, 107, ____

Namn:

Kompletterande frågor om matematisk förmåga.

1. Vad anser du om testet och ditt resultat?

2.1 Ger testet en korrekt bild av dina matematiska förmågor? Är det något testet inte besvarar?

2.2 Gick du in för testet eller ville du bara bli klar?

2.3 Hur kommer det sig att testresultatet är så skilt ifrån dina tidigare resultat på programmet?

2. Vad är dina styrkor och svagheter i matematik?

3. Vilken typ av kurser gillar du bäst och sämst? Vilken kurs är favoriten, matematik och generellt?

3.1. Har detta med upplägget att göra?

4. Hur lär du dig matematik eller kurser som använder matematik bäst?

Självvärdering efter analoga elektroniken

1. Vad tycker du rent allmänt om upplägget på undervisningen?

2. All undervisning är frivillig. Det anser jag är:

   a) mycket bra

   b) bra

   c) varken eller

   d) dåligt

   e) mycket dåligt

3. Varför?

4. Flipped classroom gör mig:

   a) mycket motiverad

   b) motiverad

   c) varken eller

   d) mindre motiverad

   e) ointresserad

5. Varför?

6. Föreläsningarna är:

   a) mycket bättre

   b) bättre

   c) varken eller

   d) sämre

e) mycket sämre

när jag kommer förberedd.

7. Att arbeta i grupp är:

a) mycket motiverande

b) motiverande

c) varken eller

d) mindre motiverande

e) ointresserant

8. Detta skulle aktivera mig mer:

9. Detta skulle motivera mig mer:

10. Därför lyckades/misslyckades jag:

Utvärdering 2015-16 – motivera gärna dina svar.

1. Uppgifterna som skulle utföras i grupp: Var de vettigt upplagda och gav en vettig fördelning av ansvar och utförande?

2. Tycker du att du fått bättre förståelse för teknikämnet elektroniska system nu?

3. Har du bättre självförtroende när det gäller dina möjligheter att arbeta som en elektroingenjör?

4. Vet du bättre vad du kan och behöver lära dig i elektroniska system? Vad har gett dig den insikten i så fall?

5. Jämför kursen med de du tidigare gått och försök beskriv skillnaden. Är det någon skillnad på hur du lagt upp ditt pluggande?

6. Vad har varit det mest drivande för dig under kursen? Vad har motiverat dig mest?

7. Utifrån dina reflektioner ovan: Vad skulle hjälpt Dig bättre under kursen? Hur skulle din motivation ökat, kunskap förbättrats, samt självförtroende i elektronikkunskap stärkts?

Appendix 7 - Recommended books about teaching in higher education

Teaching Engineering by Wankat & Oreovicz (2015)

McKeachie's Teaching tips (McKeachie & Svinicki 2013) gives the reader resolute straightforward instructions from a long career in higher education.

Felder, Woods, Stice and Rugarcia (2000) has published a series of papers, *The future of engineering education I-IV*, that contains amongst other, tools for engineering professors who want to become better teachers.

The Aalborg experiment (Enemark 1994) and The Aalborg PBL model (Kolmos, Fink, Krogh 2004) as well as Rethinking engineering education – The CDIO approach (Crawley, Malmqvist, Ostlund & Brodeur 2014), chapter 1,2 ,6 and 7, are highly recommended.

Ramsden, P. (2003). *Learning to teach in higher education*. Routledge.

Prosser, M., & Trigwell, K. (1999). *Understanding learning and teaching: The experience in higher education*. McGraw-Hill Education (UK).

Gibbs Habeshaw (Trevor and Sue) series on "53 interesting …" that are more for the unexperienced teacher in higher education.