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.

1 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.

2 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.

3 Research questions

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

4 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.

5 Methodology

5.1 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).

5.2 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.

6 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.

6.1 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.

6.2 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.

6.3 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.

6.4 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.

6.5 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.

7 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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