

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

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## ABSTRACT

The disappointment in performance of students in engineering education in traditionally deductive shaped university teaching calls for other learning environments and different teaching format (Staffas 2015). This article compares the incoming abilities of bachelor and master's students in a 2<sup>nd</sup> 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 conclusion 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 require 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 2<sup>nd</sup> 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 1<sup>st</sup> 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 20<sup>th</sup> century when John Dewey, Kurt Lewin and Jean Piaget, to mention a few, presented their theories of human learning and development. The theory is built on six propositions how new knowledge is gained (see Kolb, Kolb 2009). Facilitated group work and flipped classroom are used besides lectures and student active lessons. In a perfect world of group work there would be a very small portion of students that does not pass because not only will the combined experience and knowledge increase the problem solving ability, but it will also increase the motivation and engagement for the students to together reach the course outcomes. Therefore the groups need a stick (the exam and the assignments) as well as a carrot to get the most out of them and feed the process of learning and studying. To put learning for adults in a theoretical perspective you can apply for instance Kolb's the Learning cycle (Kolb 2014) to describe the process you have to go through to reach conceptual understanding and knowledge. An outline on his learning styles and experiential learning is to be found online by S.A. McLeod (2013). If you can implement an environment where the students' work follows a similar pattern you will most likely provide them with the best of pre-requisites and make sure that as many as possible passes. A clear advantage to encourage group work is to support all the different learning styles according to Kolb that are represented in class. It is necessary to find ways that prohibits the individuals to give up or become lazy. Therefore the groups' needs to reflect on their newfound knowledge and formulate new experiences based on the conceptual work that has been done. The course coordinator can (shall) make the group evaluate their performance themselves, AND measure the conceptual understanding individually. This makes the learning process more transparent and the teacher/tutor can at an early stage determine which of the students that probably will not keep up with the curricula.

The selection of groups was made by the students, as suggested in the Aalborg PBL model. They were instructed to form groups of 6-8 and hand in the names when they were done. In case anyone did not get a group I emailed or announced it on a lecture/lesson. The grouping process is seldom a problem when it is the students' responsibility. Often there are a number of students left over and they normally

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

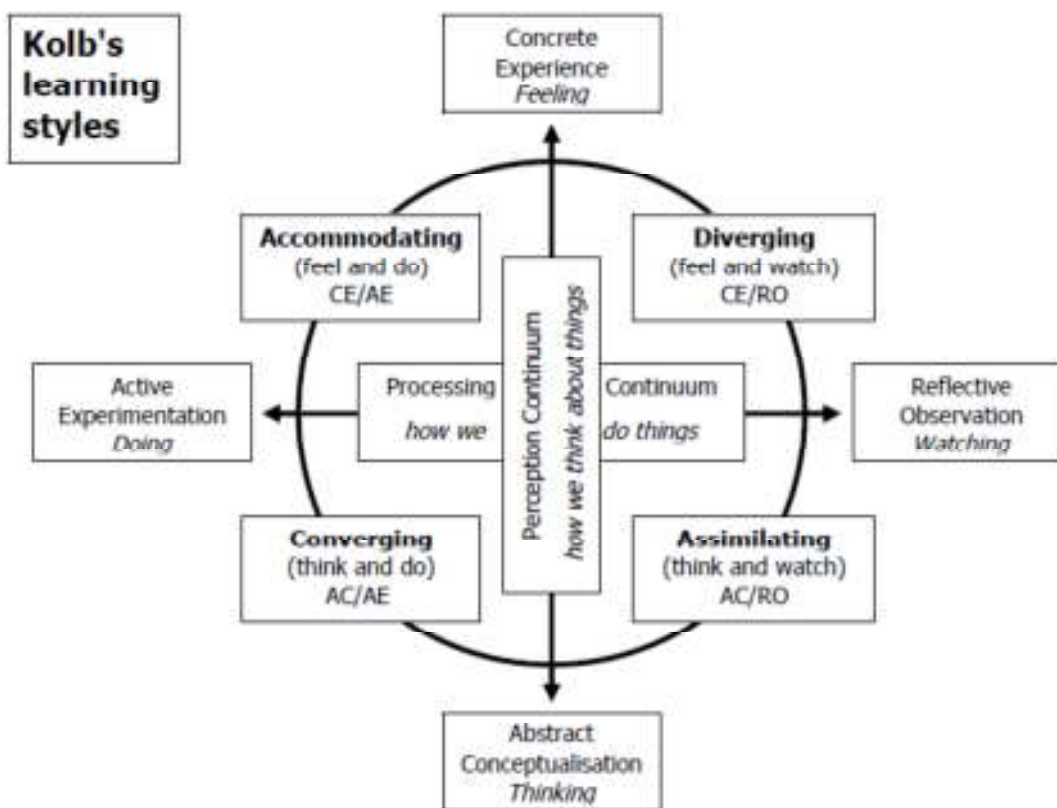
### III PROCEDURAL AND CONCEPTUAL UNDERSTANDING

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

### IV LEARNING STYLES IN GROUP WORK

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

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



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The convergent learner is shaped for higher education learning. The dominant abilities are abstract conceptualization and active experimentation making them suitable for a hypothetical/deductive reasoning on technical tasks and problems. They are particularly strong in problem solving, decision making and practical application of ideas.

The divergent learner has opposite strengths from the convergent, emphasizing concrete experience and reflective observation. Here the abilities are to view concrete situations from lots of perspectives and organize the relationships to a meaningful entirety. They are particularly strong in presenting alternative ideas and implications such as brainstorming.

In assimilation the students' strengths is in inductive reasoning and creating theoretical models. The main difference between this type compared to the convergent learner is the focus on getting it theoretically and logically correct, not the practical use or value.

The opposite to assimilate learners is the accommodative learning style. Concrete experience and active experimentation are the key ingredients to learn new things, "doing things"; the trial and error-type. This learner is not so analytic and needs ideas and information to perform well.

When presenting group work as part of the planning the awareness of these learning types should be helpful in the process making them more effective together. Also on an individual level they become aware why they respond differently and can more easily 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/universitetenochohogskolorna.4.782a298813a88dd0dad800012056.html>). It might be a tradition to almost entirely focus on the content of the course and what to exam instead of mixing it with ways to motivate the students to avoid defection and lack of motivation to study hard enough. If both components shall be covered it is necessary to do some adjustments if you are not putting in more time and effort in your teaching. One way is to create learning facilities that promotes students to work hard by themselves; i.e. not be dependent to have the teacher telling how to solve the problems that should be learned. So using student active methods can release time to focus on methods to motivate and support the students to increase their effort and motivation instead of merely prepare lecture, lessons, seminars and laboratory experiments. My experience is that the numbers of lectures and lessons given have increased. Offering different learning environments like above and reduce the number of lectures and lessons will more likely even it out. So instead of adding time on more lecturing, the time is better spent establishing contact with the student more as a facilitator and a team leader towards conceptual learning, i.e. you take full responsibility for the learning process as a teacher.

Even a philosopher like Kierkegaard believed that true instruction begins when instructors understand their student (Kierkegaard & Auden 1999). I would like to turn it around some. Of course it is of great importance to know your students, but how often can you establish that contact when classes exceeds 50 participants? You can generalise groups of students and get a decent hit in terms of graduates, but why aim for an average? If you can't invite your students to a four eye relation you can at least start by learning their names. If you learn their names you can from lecture two establish communication to the group by addressing direct comments and/or questions to the audience hence improving the teaching to be two-ways instead of just information, or "a steady stream of continuous talk" (Shernoff, 2013, p. 132). In groups larger than 50 you are more likely to be several instructors so why not divide them into manageable groups? There is no prize for lecturing the most students!

However, not all the students come from learning environments that has created engagement. According to Shernoff (2013) the one best system school in the 20<sup>th</sup> century took out all the creativity and looked at the students as a group and therefore, despite what we know about how humans learn are motivated, schools didn't teach that way. Further from Shernoff (p. 11): "A substantial literature has been established that student engagement positively impacts academic performance and achievement (Kelly 2008; Marks 2000; Sirins and Rogers-Sirin 2004; Voelkl 1997; see Fredricks et al (2004) for a review). Unfortunately, the importance of engagement is therefore reduced to its relationship to achievement. However, engagement is an important outcome of schooling in its own rights. Mounting evidence suggests that engagement is a vital protective factor and leads to a host of positive educational and social outcomes and decreases in negative emotions and behaviours (Li et al

2014; O'Farrell and Morrison 2003).” So establish a relation to your students instead of just being an authority and invite them to be a part of the process of the learning environment will promote their engagement.

The autonomy of the learner is the absolute key to motivation. Any sort of compulsion is – psychologically speaking – close to a physical forcing in terms of its negative effects on intrinsic motivation or self-motivation (Deci 1996). So if you can combine your skills to create engaging and stimulating learning tasks and still have them voluntary you have built the best foundation for most students to study hard, learn conceptually, and, hopefully, taking another step towards autonomously as a learner.

According to Shernoff (2013) Albert Einstein considered knowledge to be “dead”. So in order to gain knowledge we must “serve the living”. “The training of the will” means that the create will, and not the ability to sit and be mechanically taught, “is the driver of learning” (p. 32).

## **VI RESEARCH QUESTIONS**

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

## **VII METHODOLOGY**

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

## **VIII THE INTERVIEWS**

For the first interview all 46 students of the course were invited and 42 participated. The structure of the interview began with an icebreaker (Creswell 2009) where they freely could describe whatever came to their mind on how they experienced the course and its planning. The rest of the interview was based on three key areas; the planning, their experienced learning, and their motivation and self-efficacy. As support the following questions were pre-prepared on the motivation – self-efficacy and learning part:

*What changed for you during course: did you became more motivated, got better self-confidence, studied more or harder, got a better hold on what you were supposed to learn?*

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

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

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

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

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

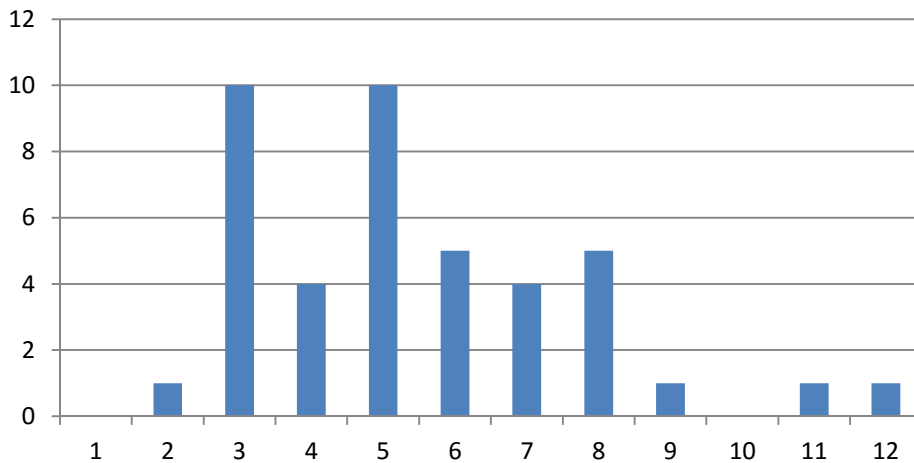
*This was by no means questions that everybody got, more like a memory card for me to keep the questioning on the right track. The overall goal was to figure out how the planning that included them working in groups affected their motivation, learning and engagement.*

## IX RESULTS

### The tests

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

### 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.

## **Conclusions**

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

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

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

## **XI THE TEACHING MODEL**

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

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

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

## **Conclusions:**

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

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

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

## **XII ADDITIONAL OBSERVATIONS**

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

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

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

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

## **XIII FUTURE INVESTIGATIONS**

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

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

How to present and instruct them to use online help during the course is something to investigate.

Should there be an evaluation of what is found? Should there be sessions where the teacher discusses different forums on the subject?

#### XIV FURTHER READING

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

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