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 from attending lecture prepared	10	25	2	-	-	1
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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