ACTIVATING TEACHING METHODS, STUDYING RESPONSES AND LEARNING

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Abstract
Students' study strategies when exposed to activating teaching methods are measured, analysed and compared to study strategies in more traditional lecture-based teaching. The resulting learning outcome is discussed.

Workshop topic
Beyond active learning

I INTRODUCTION

Teaching methods for active learning are supposed to activate the student with hands-on activities followed by critical reflection and in this way give the student a deep understanding of the subject. But how do students actually respond to activating teaching methods?

Students' study strategies have previously been investigated [2][3]. Students' approaches to learning have also been extensively analysed using the deep-surface methodology [5][6]. This method does not, however, tell what the students actually are doing when studying, and a reported correlation with study strategy was based on few data [4]. The Teaching, Studying and Learning (TEST-LEARN) project, described here, focuses specifically on the behaviour and learning outcome of students exposed to activating teaching methods in an otherwise traditional lecture-based learning environment at the Technical University of Denmark (DTU).

In the TEST-LEARN project, the students' study strategies were registered and the students were given several tests to determine their background, learning approach and learning outcome. This first report on the results from the project analyses the students' study strategies and raises some questions on the relation between study strategy and learning outcome.

II BACKGROUND: TEACHING AT DTU

Teaching at the Technical University of Denmark is characterised by
- a high proportion of elective courses
- a weekly schedule with 4-hour modules without pre-determined structure
- no control of student presence at lectures and no compulsory weekly tests
- course descriptions based on performance learning objectives
- final assessment aligned with performance learning objectives

Students have 3-6 courses of 5-10 ECTS point in parallel. A 4-hour weekly module corresponds to 5 points, which means that a student has scheduled activities (classes) 5 or 6 modules a week, or 20 to 24 hours a week. For each hour in class the student is expected to study approximately one hour at home giving an expected total weekly study load of 40-48 hours.

Even if it is not compulsory to attend classes, the studying is rather controlled compared to study programmes in e.g. human sciences. This is due to two factors:
- In an education targeted at a profession (engineering), specific core competences and skills are necessary, so entirely loosely defined, individual studying is not appropriate.
- Focus on performance learning objectives leads to a very goal oriented teaching.
This together with a new grading system, where grades are given based on the student fulfilment of the learning objectives, results in an assessment where competences and skills more than broad knowledge of a prescribed curriculum is credited.

III THE TEST-LEARN PROJECT

Previous studies [2][3] have shown that the average weekly study load at DTU was far less (30-33 hours) than the official DTU expectations (which all considered also may seem unrealistic). Students spend a lot of time on lectures and solving paper problems - and spend very little time on reading in their books or hands-on work.

In the TEST-LEARN project, three courses with a total of more than 100 bachelor students were selected for close examination. Two of the courses (the 10-point course 33253 Solid State Electronics and Micro Technology and the 5-point course 42110 Material Science) had teaching that involved a lot of activating teaching elements: practical exercises and group work combined with work on cases and short projects with poster presentations and peer evaluation.
A typical 4-hour session could be structured in the following way:
- Résumé of last session – Relatively short introductory lecture on today's topics and learning objectives
- Group work
- Time out: Plenum discussion of difficult material
- Group work – Another time-out – Group work
- Summing-up plenary session where the teacher addresses relevant issues, which turned up during the 4-hour session – Recap of learning objectives
The third course (28015 Mathematical Modeling for Chemical and Biochemical Systems – a mandatory course of the special Danish 3½-year Professional Bachelor

Engineering Education with one 4-hour module a week) had more traditional lecture-based teaching.

The investigations included:
- Pre-test to determine the students' background and pre-knowledge.
- Registration of all student activities related to the study for two weeks at mid-semester – including the students' own impression of their learning (subjective learning outcome) during the activities. 20 students were paid to register their study activities throughout the whole semester.
- Test of the students' approaches to learning [1].
- Analyses of the students' grades.
- Post-test to determine if learning had sustained over a relatively long term.

IV RESULTS

IV.1 Study strategies

The results showed that the students did not spend more time on courses with activating teaching compared to the time spent on other courses at the university, as was found in previous measurements [2][3]. The average weekly study load for course 33253 is 10.6 hours. This is comparable to the two other investigated courses considering that they only have one module a week.

The total average weekly study load for students following course 33253 is 32.9 hours. If you add the average hours spent at paid jobs, which for these students is 4.6 hours a week, you end up with 37.5 hours a week. Interestingly, this turns out to be exactly the official working week in Denmark. The total weekly study-loads for students from the two other courses investigated are approximately 2½ - 3 hours less.

The students attending courses with activating teaching spent more time when a project report had to be handed in and presented, but the workload between projects was low – especially the week after a project. The study intensity in other courses also dropped at the time a project was handed in as shown in figure 1.
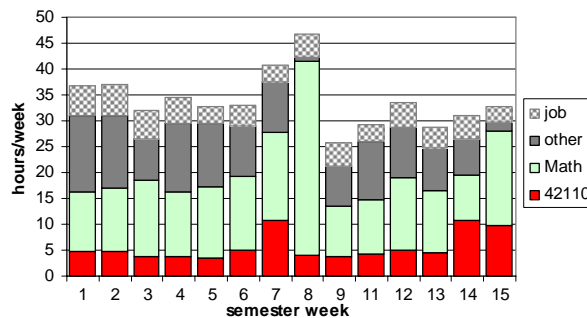

Figure 1: Workload as function of semester week for students from course 42110. Week 10 is the fall vacation. Notice the dip in week 9 after the hand-in of a large Math report in week 8.

Projects had to be presented in week 7 and 15 for course 42110. But more significantly the students had to finish a larger project in the Math class in week 8, and much more time was spent on this – it is seen that practically no studying is done in the other courses except 42110 in this week.

A doubling of workload due to a project in course 33253 in the two last weeks of the semester almost annihilates work in all other courses that the students are following.

The students have a choice between 11 different study activities, when they register their study activity for every ½-hour slot, 24 hours a day, 7 days a week.
Some activities are scheduled by the teacher and take place at the university:

lectures	Attending lectures
assignm uni	Doing assignments/problem solving at the university
group w uni	Doing group work at the university
pract work	Doing practical (hands-on) work at the university
other uni	Other activities at the university

Some activities are independent and will normally take place at home:

textbk befr	Reading textbook material before it has been presented in class
textbk after	Reading textbook material after it has been presented in class
textbk wout	Reading textbook material not presented or discussed in class
assignm hm	Doing assignments/problem solving outside class
group w hm	Doing group work outside class
other home	Other activities outside class

Figure 2 shows that in course 42110, with activating teaching, the students do far less assignment/problem solving work than in the other courses the students attend, and do much more group work and reading; especially they use three times as much time on reading text not discussed in class. Very little time was on average used for practical (hands-on) work and, surprisingly, the students with activating teaching did not register more practical work than in the more traditional course. Maybe this is due to different ideas of what hands-on work is.
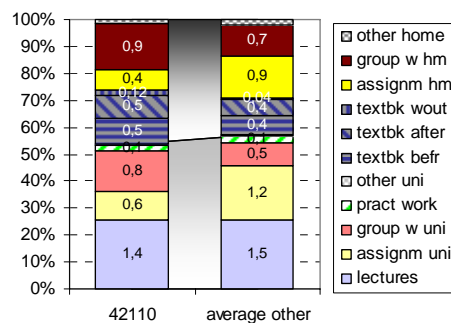

Figure 2: Relative distribution of activities. The numbers in the bars give hours/week. Shading indicates scheduled activities at the university vs. independent work at home.

It is also seen from the figure that in course 42110 the students spend more than 50% of their study time at the university. The portion of study time spent at the university is on average even a little higher for the other courses.

As shown in figure 3, the students have very different study strategies. It is seen that some students primarily read before classes and some after. Some do problem solving at home, others do not at all. The only clear difference in study strategy between students getting a low score at the exam and those getting a high score is that students getting a low score do little or no problem solving at home.
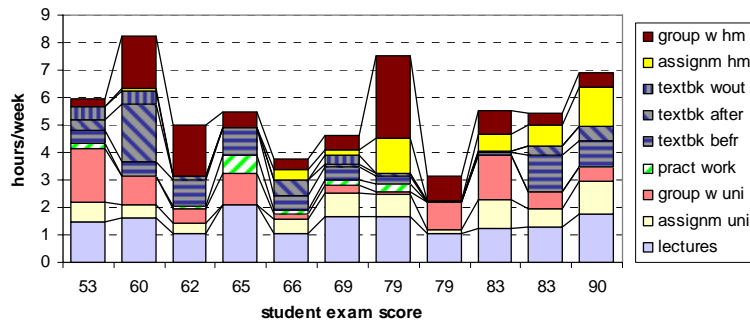

Figure 3: Study strategies for different students at course 42110. The numbers at the bottom are the students' score in the exam

As shown in figure 4 the students' study strategies also develop over time. In the beginning of the semester, all students spend almost the same time on studying, whereas there are big differences towards the end of the semester. It looks as if students getting a high exam score have a steady workload throughout the semester, and work a little more in the week before handing in a report and not in the last moment.
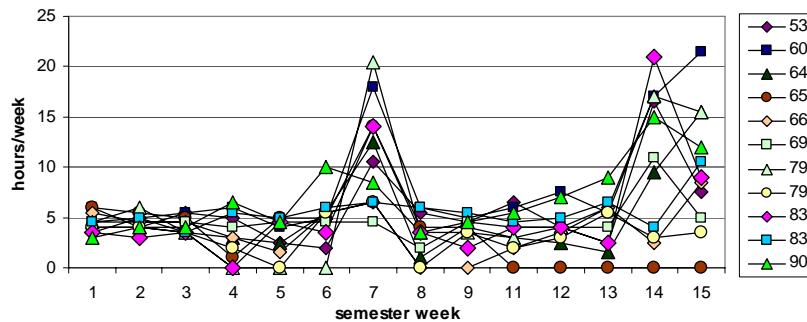

Figure 4: Time spent on course 42110 as function of time for different students. The students are identified by their exam score. No study activity may be because the student did not hand in registration for that week.

For course 28015 the distribution of activities is very different as seen in figure 5. Almost all time is spent on attending lectures and doing assignments, with little or no time left for reading or working together with other students. For 28015 more than 80 % of the study is done at the university. For all courses the average is 77 %. This high ratio of time spent at the university could be special to the professional bachelor education.
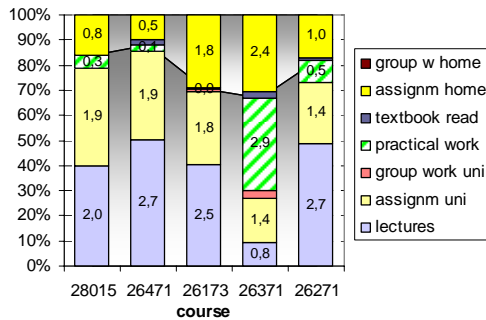
Figure 5: Overall study strategies for different courses for students from course 28015. Course 26371 is a lab course. Shading indicates activities at the university vs. independent activities.

It is seen from figure 6 that the students are most active in the two 4-hour modules: 8-12 and 13-17. Inspection of the kind of activity the students are involved in reveals that they are attending lectures in the first half of the modules and doing assignments in the last half. So giving the teachers the opportunity to freely plan the 4-hour modules has not introduced much innovation. Most have stuck to the convention: First you lecture and then you give students assignment to practice what they (should) have learned.
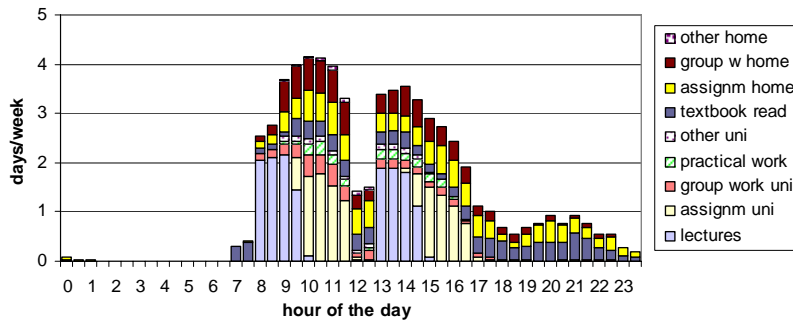

Figure 6: Study activity as function of time of day for students from course 33253. The graph is read in the following way: A value of 4 means that the student 4 days out of the 7-day week was studying at this ½-hour interval.

It is seen from figure 7 that the students more or less adopt a 4-day week Monday-Thursday. This is due to a loop with positive feedback. Students tend to leave early Friday, so teachers don't want to have classes Friday, making students skip the few classes left. Wednesday is a little different since you don't have two 4-hour modules this day, but one 8-hour module. Many teachers don't like to teach a full day, so Wednesday has fewer classes, and an inspection would show that most activities on Wednesday are done at home.

The daily and weekly profiles for the two other courses are similar. And data showing when students are logged on to the DTU's intranet confirm that the 4-day week is very common.
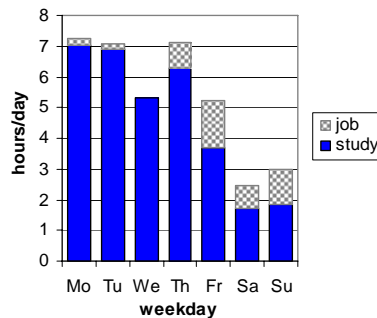
Figure 7: Study time and time for working for money as function of day of the week for students from course 33253. Wednesday has a special schedule.

IV.2 A few other results

The pre-test for course 28015 showed that motivation and pre-knowledge did not have a strong correlation with the exam result. But the students were very good at guessing which grade they would get in the end!

The students from course 42110 felt they had the biggest subjective learning outcome from activities at home: reading textbooks, doing assignment and working in groups, and the lowest outcome from scheduled activities at the university – especially attending lectures.

In course 42110 there is, as the theory predicts, a positive correlation between grades and a deep learning approach. There is also a positive correlation between grade and how much time the student uses on answering assignments at home. And there is a positive correlation between the grade and the score in the post-test; the students actually remember what they have learned!

V DISCUSSION AND CONCLUSIONS

Contrary to the expectations of the authors, the students did not spend more time on courses with activating teaching. As is seen and expected for the course with traditional teaching, also for the courses with activating teaching the only positive correlation between grades and study strategy is with time spent on problem solving. Is a lot of paper problem solving necessary to get a good understanding, or is this correlation unavoidable due to the way courses are assessed at DTU with focus on performance learning objectives?

It is no surprise that doing a project in one course takes student time away from other courses. Here it is demonstrated how bad it can go if two courses (42110 and the Math course) have projects almost at the same time – it takes the students two weeks to get back to normal workload, although it seems that the activating teaching in course 42110 keeps the students working to some extent. And there is an indication that steady workload during the semester is fostering good grades – especially if you spread the high workload of projects.

One big question remains: How much time should a student spend on scheduled activities at the university and how much on individual independent activities? Even though activating teaching does seem to stimulate reading on your own, activating teaching methods also tend to keep the student at the university, and that is good – but how much should the teacher be in control? Is it inherent and natural to engineering education to keep the students occupied with fixed tasks?

And what qualifies as hands-on activities? Do students experience hands-on activities as practical work with relation to reality – or it is just another exercise that has to be dealt with?

Further work has still to be done on the very large date set, but it is possible to make a conclusion: Even with very enthusiastic and engaged teachers with a very activating teaching methodology, it is difficult in a traditional teaching environment to change the students' study habits. However, even if the activity and study intensity is not as high as expected, it seems that the learning outcome is deep-rooted.

ACKNOWLEDGMENTS

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