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Teaching a subject which is a tool for the subject the students are actually interested in

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Introduction

When I first started high school, one of my new classmates would in almost every single lesson ask the teachers “But what’s the use?” [of what they were trying to teach us]. Having failed to get the answers he was looking for, after about two months he dropped out. While one could argue that he was just not cut out for the very generally educating and maturing exercise that Danish high school essentially was at the time, this story illustrates an important issue in student motivation and thus learning outcome. While a few students are interested in learning for learning’s sake, for the majority *relevance* of the subject taught is a key motivating factor (Biggs and Tang; 2007). University courses are often structured in a way so that a series of individual teachers sequentially teach their favorite subject. This has the advantage of being able to offer students teachers who are all experts in their given subject and highly engaged in it too (and hopefully also engaged in teaching it). However, in this way the course may also become somewhat fragmented and have little connection between the different subjects taught. Some of these subjects may even be mere tools for the other ones and for the overall course subject. Under these circumstances, convincing the students of the relevance of such “tool subjects” and getting them engaged and motivated to learn is a challenge.

Project background and aim

I was given the opportunity to teach a new subject at an existing course offered to B.Sc. and M.Sc. students. In addition to the subject being new to the course, it was also my first experience of teaching other than lab exercises and of being responsible for an entire subject. This year I will be teaching the same again and I wish to re-think the structure of my teaching. The aim of this project is to plan this year's teaching to improve learning outcome, with special emphasis on student motivation and teaching/learning activities (TLAs).

Course and subject outline

The course I am teaching is called "Plant Genomics", and my subject is "Metabolite profiling". Whereas this subject mainly deals with analytical chemistry, the majority of students would have chosen the course because they are interested in some aspect of biology or biotech – and many of these will traditionally think of chemistry as torture. The book from which I am forced to take my main curriculum has two chapters presenting an unfocused, superficial and not very informative overview of my subject. In addition to this I supply a research paper as part of the curriculum. While metabolite profiling is not mentioned in the course contents or intended learning outcomes (ILOs), several of the points mentioned there require or can include application of metabolite profiling (see Appendix A).

Motivation

According to the expectancy-value theory, for all those students who are like my ex-class mate from high school, motivation to engage in achieving the teacher's intended learning outcomes can be facilitated by two factors (Biggs and Tang; 2007):

- *Relevance* or *personal value*; the student has to feel that this is important to him/her.
- *Success expectancy*; the student must feel likely to be successful if engaging in the learning.

According to Biggs and Tang (2007) this is mainly important in the early stages of learning “before interest has developed to carry continuing engagement along with it”. I would argue that it continues to be important for mature students throughout their learning life, even more so at the fragmented type courses dealt with here. While the students at this point may have developed a wish to learn the *title subject* of the course and chosen it according to interest, they will most likely need a guiding light to help them grasp why all the little individual subjects on this course are important for the overall subject.

Learning can have value for the student in different ways, leading to four different kinds of motivation: *extrinsic, social, achievement* and *intrinsic* motivation. The first three more or less encourage surface learning approaches; the balls that the students have their eyes on are not related to learning, but rather to the reward obtained from success, from the recognition and acceptance of specific people, or simply from doing better than someone else. *Intrinsic* motivation is when the student is interested in the learning activity – or the subject – itself and enjoys engaging in it and taking a deep learning approach. Luckily, intrinsic motivation is not static, but can be induced by the perception of *relevance*; if the subject is of personal value to the student, he/she will gain interest in learning it. If, moreover, the teacher can also manage to create a feeling in the student that *success* can realistically be obtained in the subject, he/she will eventually take *ownership* of the process and actively pursue learning (Biggs and Tang; 2007). Thus, in my case, it is all about convincing the students that the tool I am teaching is of major importance to their understanding of their overall subject of interest.

Teaching/learning activities

Overall, there can be no doubt that students learn more if they participate actively in the teaching/learning process, rather than constantly assuming a passive role as audience. Even hard headed supporters of ‘good ol’ fashioned’ auditorium lecturing (teachers and students) will for the most part have realized that it works better if there is some sort of student interaction along the way. The question is how to provide appropriate interactive teaching. Obvious (and some would say classical) choices are lab exercises, report writing and some sort of tutorials. These are all integrated parts of my teaching and with them my concern is on increasing their relevance to the students and motivating them to take ownership, the theory of which I have already described. However, so far I have stuck to the idea of doing parts of my teaching the auditorium way, and I am looking for means to activate and engage the students.

Biggs and Tang (2007) have a very illustrative table of the activities that the teacher and learner respectively engage in during a lecture without interactive elements (Figure 19.1). Course ILOs often require the students to be able to explain, understand or even apply the matter introduced to them; this is indeed the case for those points in the course ILOs where my teaching fits in (Appendix A). Common to this type of ILOs is that letting students explain the matter themselves rather than only listening to the explanation will facilitate achievement. It will force them to reflect on what they have learned, reconstruct it in their own words and locate the holes; things they have not understood or have misunderstood. There are various ways of engaging them in the explaining process, e.g.:

- Group discussions of appropriate questions, forcing them to argue their case to their peers.
- Explaining the answers to the class.
- Preparation assignments.
- Explaining to their neighbor or to the teacher in written form what was just learned.

These themes can be varied, e.g. after class discussions of the questions assessed in groups, form new groups of opposing ideas and continue discussions; discuss the preparation assignments in class or in groups etc. While preparation assignments can help the students focus and reflect while studying at home, the discussion/explaining activities in class at the same time address a more technical issue: students can only function well as passive listeners for 10-15 minutes. In order to maintain a high level of learning efficiency, every 10-15 minutes there must be a change in activity (Biggs and Tang (2007) from Bligh (1972)); the discussion sessions are perfect for this. In addition, it has been shown that getting students to review what they learned at the end of each lecture will greatly enhance how long they remember what they learned (Biggs and Tang (2007) from Bligh (1972)).

Summing up, for my two hours “lecture theatre performance”, in addition to the one or two no-teaching breaks the students will have, I should come up with three or four interactive assignments of about 10-15 minutes, plus a review session at the end. There are other ways of activating students than those mentioned above, but here I have pulled out those that

	Teacher activity	Student activity
1	Introduce	Listen
2	Explain	Take notes
3	Elaborate	Understand (correctly? deeply?)
4	Show some PPT slides	Watch, note points
5	Questions on slides	Write answers
6	Wind up	Possibly ask a question

Fig. 19.1. Teacher vs. learner activities during lecturing (reproduced from Biggs and Tang (2007))

I find suit me. Also, as the more applied aspects of my subject come into play in the other elements of my teaching, I want to focus on the discussion/explanation activities in the lecture based teaching.

New teaching plan

Structure

My overall plan for the sequence of teaching elements and their interrelationship is shown in Figure 19.2, panel A. The idea is that the two parts of the curriculum (text book and research paper) both form basis for the initial lecture session where the subject is introduced. The remaining elements are then built on top of the introduction, with the text book and the discussions in the first session forming the basic knowledge bank for understanding the rest. The research article forms a direct basis for all elements of the teaching:

- "Lecture": discussions.
- Lab exercise: the students repeat parts of the experimental work of the paper.
- Computer exercise: students work on their own results from the lab, using the paper as reference for whether their experiments have worked or not.
- Report: the students finally hand in a report on the lab exercise, which will necessarily be based on the computer exercise and the paper.

The point being to add *relevance* to the students on (at least) two levels: 1. the research paper demonstrates how metabolite profiling is used in plant genomics research in real life, and 2. the coherence between the individual elements makes it clear that they need to learn something from the earlier elements to be able to produce a product in the end. Whether they find this final product relevant or not is another matter, which should hopefully be taken care of in the introductory session; more about this below.

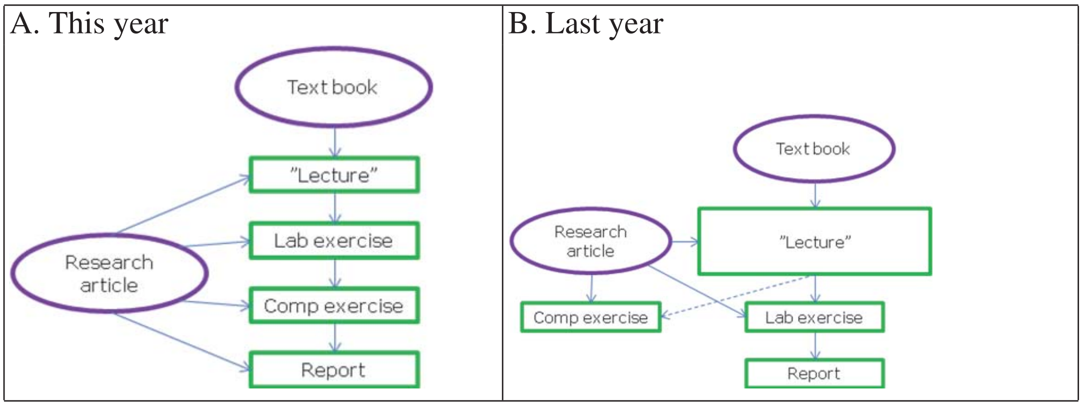

Fig. 19.2. Schematic of this year's and last year's teaching plans. Comp exercise = computer exercise. "Lecture" refers to the auditorium based teaching.

Comparing this year's plan to that of last year (panel A vs. panel B of Figure 19.2), the elements are exactly the same but there are two major differences. The first is that I have reduced the overall time spent on my subject drastically; this has been achieved by cutting the lecture based part down to about one third of last year. The reason for this simply being that I felt metabolite profiling had been given too much weight on the course than the ILOs and the position of this subject compared to others justified. This in turn had the unfortunate effect last year that I managed to overload the students with too many details, leaving them rather confused. I had this feeling as I went along, but it became evident when I saw the course evaluations and the exam results. The latter had a direct reference to my teaching, as I and another teacher in combination asked a question for the four hour written exam where two out of three sub-questions dealt with my subject. The first question mainly related to what they were supposed to have learned from the lecture based teaching. The result was that only 18 out of 30 students understood this question to some extent, and out of these only a handful gave the answer I was actually looking for, dealing with the overall application of metabolite profiling in plant genomics. The rest answered a lot of insignificant details, not surprisingly believing that these were the important points because I had spent so much time on them! A comment in the course evaluations further supports this feeling, in that the student raises the point that the whole course in its fragmented style goes into too much detail and makes it difficult for the students to work out what are the major points connecting it all – and what should they focus on when studying. An element from my lecturing was mentioned as one of these nitty-gritty details (Appendix B).

The other major change of plans compared to last year is that I have managed to integrate the computer exercise into the lab exercise and thus report (trust me, this is not easily done when working under the seven week bloc structure; plants take the time plants take to grow). The computer exercise itself was a success last year; the students were happy and participated very actively in this session, and the message got through; 23 out of 30 students answered the exam question with relation to the computer exercise completely correctly, including explanations. However, computer exercise standing alone, the details learned from this are also in danger of coming across as if they are more much more important than the overall lines of the subject. Furthermore, in the evaluations and during the lab exercise there were complaints from the students that they were not allowed to do all the work themselves (due to time restrictions we had to analyze their samples and extract the data for them). This year we will still have to do the analyses for them, but they will be allowed to extract the data themselves and the focus of the computer exercise will be on identifying the genotype of their own transgenic plants, rather than on how they do it. The exercise is the same and the things they need to learn to reach the goal are the same, but the goal focuses on the overall lines of the subject and the course rather than the details of the technique.

In addition, my slot has been moved so it is now situated much later in the course. This makes it a lot easier to include other elements from the course in my teaching, thus adding *relevance* of my subject to the students.

Interactive elements in “lecture” session

Rather than going through an exhaustive list of planned interactive elements I will pull out a few examples to illustrate my considerations. The overall ILOs of my teaching are:

- Understand how metabolite profiling can be used in plant genomics

- Be able to select appropriate analytical approaches for a given problem
- Be able to evaluate experimental conclusions >< techniques used in other people's work

The first bullet point is an ILO as well as a crucial factor in adding *relevance* of the subject to the students; this is the reason why my subject is taught on this course! As such, this issue needs to be addressed early in the process and enough time should be spent on it to add significance and understanding. The text book chapter on metabolite profiling starts with a useful introduction to the terminology of the subject. There are four approaches to metabolite profiling, ranging from less to more comprehensive; each of these are appropriate for each their generic type of genomics "problem". Last year I used these definitions to illustrate the first bullet point and add relevance by showing them the connections:

Target analysis: gene of interest → *analysis for products of suspected reaction* → verification of gene function

Extended target analysis: pathway or network of interest → *analysis for substrates and products of pathway* → indication of gene function/selection of gene of interest

Global metabolite profiling: phenotype/gene of interest/effect of treatment → *analysis of entire metabolome* → indication of gene function/selection of gene of interest

Screening: natural variation/mutant population → *fast high throughput analysis for classes of metabolites* → selection of plant(s) or gene(s) of interest

Thus, I tried to teach the students this very important point in Table 1 style. This year I will instead give them the assignment to discuss first in groups and afterwards explain and discuss in class:

"Using the terminology presented on pp. 312-313 which approaches would you use in the following situations. . . ?"

The "situations" will be taken from other parts of the course. E.g. three weeks earlier in the course they have been taught about forward and reverse genetics; a metabolite profiling approach to identify gene or assign gene function would be respectively target or extended target analysis for forward genetics, and extended target analysis or global metabolite profiling for reverse genetics. In addition to adding *relevance* this assignment should also allow most students to feel *successful* from the beginning: 1. The majority of students will be able to deduce the connection from the text book, 2. Hopefully many of them will realize that something they already know about (e.g. forward and reverse genetics) can help them in learning this subject, and 3. There are no uniquely correct answers, so they can get it right even if they do not agree with their neighbor.

The remaining bullet points of the ILOs relate more to technical details of metabolite profiling. This is where the text book gets confusing and I went into too much detail last year. In order to balance the focusing on details against the abilities to overall select and evaluate analytical approaches I will give short assignments on the details and a longer finalizing one directly addressing the two ILOs.

Example of short assignments: I present a molecule (metabolite) and two extraction methods, ask the students to give a vote on which should be used and then ask them to discuss with one of opposing opinion and repeat the vote. This I will do for various combinations of metabolites and techniques, and at the end most of the students will have had to do some quick initial thinking by themselves and later explain their conclusions to their peers.

Example of summarizing assignment to be discussed in groups: following the short discussions about metabolites vs. techniques, I will pose case based questions such as:

"Why did they choose these analytical methods in the research paper? Are they missing out on some metabolic information, and if yes, what kind?"

A Appendix: Metabolite profiling in relation to the ILOs of Plant Genomics

The course will provide *basic understanding* of the structure and evolution *of* plant genomes and *central techniques used for studies of genomes and molecular breeding* through a combination of lectures, cases, wet-lab exercises and computer exercises. *Focus will be on the relationship between phenotypic traits and genotypes* using the expanding information and resources on plant genomes and RNA/DNA/protein sequences. The course begins with the genomics and central techniques and databases developed for the two main plant model species, rice and Arabidopsis, and translates the principles to cultivated crops to understand the potential and constraints of applying genomic technology for plant breeding.

After completing the course the students should be able to:
Knowledge

- Describe basic principles for the study of major model plants and general plant evolution.
- Classify genetic markers and their use for qualitative and quantitative traits
- *Describe basic central experimental techniques used in plant genomics and molecular breeding*.

Skills

- Integrate basic knowledge on plants to understand complex biological processes using plant model systems.
- *Apply molecular and genetic tools for plant improvement through molecular breeding of crops for food, fodder and production of high value crops for e.g. biomedicine, biofuel, green factories, etc*.

Competences

- *Evaluate various forward and reverse genomics approaches for gene isolation and functional studies*.
- Relate gene differences with phenotype by means of genomics
- *Discuss the ethical aspects of the use of new molecular approaches in plant biotechnology e.g in relation to biodiversity*.

B Appendix: Selected comment from student evaluation of the Plant Genomics course 2008

"Overall I enjoyed this course, but I felt there were a few problems that kept it from being outstanding. The most glaring of these to me was how esoteric the material was at times. Individual lecturers would talk in depth about very specific material without adequately tying it to the overall themes of the course. Granted, this wouldn't have been such a problem if everyone in the class had a strong background in genetics, but this was not the case. Many students got lost, it seems, in minute details when the general topics were more important. This makes studying for the exam quite difficult. . . should we be focusing on the genetic structure of a transposon or the inner workings of a mass spectrometer? Or should we focus on understanding why forward genetics is useful in certain situations? etc etc. The fact that many different teachers were involved made this problem more apparent. I appreciate that we got instruction from many different people who had strong backgrounds in different things, but it led to great variation in detail and style."

All contributions to this volume can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/2008-1/

The bibliography can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/kapitler/2008_vol1_bibliography.pdf/