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Developing new teaching material for a BSc course: Student activating lectures

Kathrin Rousk

Department of Biology
University of Copenhagen

Background

I was asked to teach in the BSc course "*Plant Ecophysiology*", taught at the Dept. of Biology, Univ. of Copenhagen. This course is an elective course in block 3. While the course has been taught for several years, some topics that are listed in the course description have not been included in the curriculum, and I was asked if I could teach those topics. Since it has not been taught before, I had to develop the teaching material without any examples or guidance from previous teaching sessions. I was asked to teach two different topics: (1) *Plant growth regulation* and (2) *Nitrogen Deposition, Growth and Nutrient Uptake of Mosses, Cyanobacteria and Nitrogen Fixation*. The first topic was taught from 11 – 12 am and from 1– 4 pm the same day, and the second topic was scheduled for 1 – 4 pm another day. Twenty-three students were present at these teaching sessions.

Challenges in designing new course content

There are several challenges to be encountered when planning new course material. The most important or most challenging parts for me are (1) to take the students' competences, learning and background into account when planning the course; (2) to translate the intended learning outcomes (ILO) into pedagogical practice; (3) planning according to the student learning and not the logic of the material (e.g. Knight, 2002). During the planning of the new course material, I tried to incorporate these issues and

to accommodate those during the teaching sessions by e.g. probing the students' knowledge on each particular subject in the beginning of each teaching session, by stating the ILOs clearly in the beginning, and re-visiting them in the end.

A Pedagogic Perspective

Lectures are a time and cost efficient way to "teach" a large group of students. Yet, listening to a monologue is not as efficient as reading by yourself. Listening is a passive way of acquiring knowledge, while reading engages the mind, allows for exploration of ideas etc. Despite "traditional" lectures promoting often surface learning only, we are still using this form of teaching predominantly, out of habit, because we do not have enough time to explore alternatives etc. Shall we abandon lecturing altogether? Lectures still can give the students a sense for the material; they are opportunities to present a broader picture, to relate theories to observations, to provide a different perspective, and to explore topics not covered in the reading material. Further, by re-structuring and re-revising lecture-like teaching, we can achieve actual learning by the students.

Trigwell, Prosser, and Waterhouse, 1999 highlights that many studies have established a consistent relationship between surface approaches to learning and lower quality learning outcomes. Thus, if we want to achieve "deep learning" by the students, we have to guide them to construct a deeper understanding of topics by connecting old with new knowledge. This can be achieved by activating the students; making them think by themselves and having them solve problems. All of this is possible in a lecture teaching session. Trigwell et al., 1999 also note that those teachers who have the student as the focus of their activities, by encouraging self-directed learning, are more likely to encourage a deeper approach to learning.

Another problem is that lectures are often too long, and the attention of the students decreases after few minutes. Adults can keep an attention span in a lecture for no more than 15-20 minutes at a time (see e.g. Middendorf and Kalish, 1996 and references therein). Jenkins, 1992 argues that just breaking up lectures into short segments can act against that. These short segments can be achieved by simple breaks of the entire teaching situation, or by involving the students in group or pair exercises or discussions. Here, the students work actively and feel personally involved. Along those lines, Meade, 1997 identifies the most significant change facing universities is

to expand the traditional teacher-centered method of teaching to include a greater range of student-centered learning methods. These can include case studies, peer assessment and group work.

Our brain handles information by reducing it into meaningful chunks (categories), and learning consists of fitting new information into already existing categories, or forming new ones. The students need to practice thinking with these new concepts. In a classroom situation, this can be achieved by asking the students to explain the new concept to a neighbor, to summarize it, to apply it etc. (Middendorf and Kalish, 1996).

Every student learns differently. Some students prefer or learn best via sensory input (sights, sounds etc.), others intuitively (insights etc.), and how students prefer the communication and organization of information (inductive vs. deductive) is student specific (Felder, 1988). This poses challenges to the teacher. However, by alternating and mixing teaching input types and the organization of information during a teaching session, the teacher has the possibility to accommodate problems arising due to that. Further, by allowing intervals for the students to think about what they have learned, the teacher facilitates reflective thinking. Interspersing a lecture with student activities keeps the student attentive and active. In particular, if the students are asked to explain new concepts or ideas to their peers, reflective and synthesizing thinking is promoted (e.g. Felder, 1988).

This paper describes the planning, implementation and evaluation of my newly developed teaching material. I will describe and discuss the two topics taught separately.

Topic 1: Planning and implementation

Ideas and Teaching Plan for the topic *Plant growth regulation*

The "problem" with this course day is that the topic is new to me. I am not an expert on this topic, and it is very much outside of my expertise. Also, this topic has never been taught before in the course. The advantage is that I can decide what and how to teach, although the topic and content is given by the textbook, which the students have to read.

My plan was to give an overview of each topic that is covered in the textbook with an interactive lecture. In particular, I will ask questions in between (every 3-5 minutes) to keep the students active, and the students are encouraged to ask me questions in between. I will avoid using the textbook too much in the teaching session, the students will have to read the

textbook chapter anyway, and I do not want to repeat their reading material. This also means that the students have to take the responsibility and to have sufficient interest in the topic to work on their own.

To keep the students motivated and active through the entire teaching session, I will include aspects of the topic the students can relate to. E.g. How are the red "leaves" in the Christmas star (-plant) achieved? etc. Throughout the entire teaching session (4 h in total), I will ask the students to do several short exercises relating to the topics presented. This will be done in the manner of the "didactic game" (see Table 5.1): I will introduce the exercise (devolution), have the students deal with a problem in small groups (action), have the students present their thoughts and suggestions for solutions to the class (formulation), and we will assess their ideas together in the class (validation). The group size will depend on how many students will be there, but I was planning with 5 students per group. The students will have to complete 4 exercises throughout the teaching session.

To accommodate different learning styles (e.g. Felder, 1988), I try to motivate learning by relating the material to the rest of the course, by using different types of information (facts, data, experiments, concepts), and support creative questions and solutions.

Action	*Phase in the didactic game*
Question or problem is presented	Devolution
The students discuss the question/problem in small groups	Action
One group presents their solution in plenum	Formulation
The group receives feedback, and other groups are invited to the discussion	Validation
The solution is presented	Institutionalization

Table 5.1: Structure of the "didactic game"

Outcome of the teaching session / Reflection, Topic 1

Overall, the teaching session went nicely. The students were active, asked questions and completed the exercises. The students had a long teaching day, starting at 9am until 4pm, and most of the teaching was in the form of lectures, sitting in the same room all day. Yet, the students kept being active until the end of the session, and I made sure that I asked and involved the class every 3-5 minutes. However, it was always the same few students that answered my questions. Asking questions every 3-5 minutes might be too much, decreasing the frequency of questions might counteract this issue.

I started the session by introducing myself, followed by the ILOs for this session, which I re-visited at the end of the session with the help of the students. I.e. I posted the ILOs and asked the students if/how we have achieved those, which worked well. This was also done for the second teaching session I describe below.

I tried to break up my "lecture" with short exercises. The book chapter, the students were supposed to read was content rich, and I though it would be best to introduce every sub-topic with an interactive lecture (asking many questions in between) for ca. 20 min, and to conclude each sub-topic with a short exercise, which worked time wise as planned.

The exercises were done in student groups of 5, and they had ca. 5-8 minutes for the group discussion. For the small exercises to be dealt with in small groups, I picked the group that should present their ideas and results, to make sure that not the same students respond. That worked well. However, given that the students used their computers, and could look up topics, the exercises might have been too easy to solve for them. On the other hand, the exercises were thought to promote discussion within the group, as well as to break up the lecture part, which worked well.

Although it went fine, I am not sure if I would do it the same way again. It was very exhausting for me as a teacher to "entertain", be attentive and respond for 4 hours. For another teaching session, I will consider giving the students fewer but longer exercises, e.g. 30 min for an exercise with 15 min. discussion afterwards. This would be less exhausting for the students and for me. Also, in this teaching situation, all student groups got the same exercise to solve. Maybe it would be more interesting to develop different exercises for different groups and then the students have to describe their exercise and explain and justify their solutions to the entire class, without repeating the other groups' discussion points.

To conclude, the teaching session went okay, but in the future, I could imagine trying something different, e.g. fewer but longer exercises and different exercises for the different groups to promote discussion in the entire class. But on the other hand, that would require more preparation time for the teacher, which most of us do not have.

Topic 2: Planning and implementation

Ideas and Teaching Plan for the topics *Nitrogen Deposition, Growth and Nutrient Uptake of Mosses, Cyanobacteria and Nitrogen Fixation*

Given the above described findings and suggestions (deep learning approach), I will try to keep the students activated (see below), I will set time aside for breaks as well as for group work. In this three-hour slot, I aim to cover three topics that have not been taught before in this course. Further, the students do not have a textbook for this particular topic. Although the topics have overlaps with my own research, it does pose some challenges to me as a teacher since it is difficult to get the level and depth of the topics and teaching right. What seems obvious to me might be completely news to the students. To try to accommodate for that, I will pose a question in the very beginning of the teaching session to "probe" the knowledge of the students, and hope I can revise my teaching accordingly during the session. I will ask questions throughout the teaching session to make sure the students are still following, and also to keep them activated. My plan for the teaching session is to deal with each topic (3 in total) for ca. 45 minutes. That gives enough time for breaks in between, as well as enough time in the end, in case it would be needed. I am planning to introduce each topic with a "hook" e.g. newspaper headline, a question to be solved in pairs, or nice photos to get the students' attention. Then, I would like to give short lecture-like overviews on each topic. These short overviews will be interactive, that is, I will try to keep the students active by asking questions in between. The short introductive lectures will be for ca. 20 – 30 minutes, after which we have 25 – 15 minutes time for group work (4 – 5 students). The students will have ca. 5 minutes to discuss the exercise I will give them in small groups, after which we will discuss their conclusions and suggestions in plenum (10 – 20 minutes).

After teaching the same group last week, I thought I could introduce something practical. The students are sitting in the same room since 9am, and I noticed they were getting tired in the afternoon. I would like to do a short demonstration of how mosses can change their surrounding by decreasing the pH. This takes some minutes, and I will need to start setting up the experiment first thing in the teaching session. After the setting up, I will start with the teaching session, and we will check the "experiment" during the second topic of the teaching session ("moss growth"), after ca. 1 h. That gives the students time to think about the experiment and to formulate hypotheses and possible explanations. The demonstration will be short, thus,

I will still use also the short exercises for each of the three topics. I will ask two students to volunteer to help me setting up the experiment since the entire class would not fit around the table and would not be able to see the experimental set-up.

In this teaching session I will use a mix of teaching methods: a practical demonstration, discussion-groups, pair-share and an interactive lecture.

1. Exercise and group work: the students will get a world map and they have to guess and mark where they think high and low nitrogen deposition takes place, and they should be able to give reasons for their guesses. This will be followed by a plenum discussion, and a resolution (see Table 5.1). Thus, this group work will be structured like a "didactic game": I will introduce the background and exercise (devolution), have the students deal with a problem in small groups (action), have the students present their thoughts and suggestions for solutions to the class (formulation), and we will assess their ideas together in the class (validation). The last step of the "didactic game" (institutionalization) will not be very pronounced for this exercise, but they will need the acquired knowledge to be able to solve the last exercise for topic 3.

2. Exercise and group work: the students will get data in small groups and I will ask them to study the data so that they can come up with a description that can explain the findings. The ideas from the different groups will be discussed in the class, and I will finish this part with the resolution.

3. Pair-Share: I pose a question to the class, and the students will be able to discuss the problem/solution with their neighbors, before they are asked to present their solution to the class. The answers by the student will be institutionalized with my own research data, and will be connected back to the first exercise.

Outcome of the teaching session / Reflection, Topic 2

This session went nicely. The topic was closer to my own research, and I felt more comfortable teaching it. Further, I could intersperse the lecture with my own research, which is fun for me, and gets the students interested, and gives them insights into research.

After the introduction (welcoming etc.), I started with the demonstration experiment, for which I had two volunteers to help me. The demonstration went well, the students seemed interested. The students could see by themselves what happened instead of just being shown a graph by me. When I asked them (after 1 h) what happened and why, the students came

up with explanations and seemed to have understood the underlying mechanisms.

The interactive lecture worked well. The students responded to my questions, and they were active until the end of the 3 h session. The two exercises, which they had to solve in small discussion groups worked nicely. I could see that each group was discussing the problem and all groups completed the exercise. I picked one group to present their solution to the entire class, which also worked well.

I also brought a moss sample to for the second part of the lecture, which I gave around so that each student could "feel" what a moss is. We could then discuss what is "special" about mosses, and what are the differences compared to vascular plants. This helped the students who learn best via sensory input.

Towards the end of the lecture, I demonstrated how we measure nitrogen fixation in the laboratory. I brought a sample from a running experiment and explained where it came from (Disko island), and what we are doing with the samples (exposing it to freeze-thaw cycles). This got the students interested and they got to see how we are implementing experiments.

The overall timing of the 3 h session went well. We had short breaks after each topic, so that the break in content overlapped with a physical break.

Improvements for the future

Besides what I mentioned already in the text above (e.g. longer but fewer exercises), I could be better in asking follow-up questions to students after they have given me an answer to my questions. Similarly, I could invite the group to a discussion on a question posed by the student, instead of only me giving the answers. When I ask follow-up questions, I should be better in keeping the intended learning outcomes (ILO's) in my mind to get the students to understand and achieve the ILO's. I should further use the ILO's more during a teaching session, to connect the topics and discussions back to them. The topics I am teaching provide the possibility for case based teaching, which I aim to try in the future.

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