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Teaching plant-animal interactions with active student participation and deep learning

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Introduction

Teachers can improve their performance and thus students' learning outcome through systematic reflection on their teaching (Sølberg, 2015). And teaching and learning can be improved by adding variation in teaching methods and learning activities (Weimer, 1990). This paper reports the results of a didactical research project and is a reflection on planning and teaching a three-hour session for master students in the course 'Plant Animal Interactions. An Evolutionary Approach' in the fall semester 2016 at the University of Copenhagen. I used recommendations described by Peter Stray Jørgensen (Jørgensen, 2015) and Donald A. Bligh (Bligh, 2000) to plan the session. The aim of the research project was to identify teaching methods that improve the student learning outcome of my teaching. I did this by adding five diverse learning activities throughout the session (lectures, microscopy, student experiment, experiment analysis, and presentation of experiment results). The students evaluated the perceived effectiveness of each learning activity immediately after the session in a questionnaire.

Background

Learning outcome of lectures

According to Donald A. Bligh, lectures are relatively ineffective for goals of teaching that go beyond the transmission of information (Bligh, 2000).

Such goals beyond the transmission of information are values, inspiring interest in a subject, teaching behavioral skills as well as personal and social adjustment (Bligh, 2000). Several methods have been suggested to overcome these limitations. Some examples:

- Courses and sessions should incorporate learning objectives and learning outcomes (Biggs and Tang, 2007).
- Students should be recognized in the didactic triangle, with the three corners referring to teacher, student, and content (Gundem and Hopmann, 2002). Teaching is a complex activity and the relationship between teachers and students, the teachers' communicating role, and the students' learning process are crucial to the quality of teaching (Mørcke and Rump, 2015). As content turns the interaction between students and teachers into teaching, the choice of content is fundamental in the didactic triangle (Mørcke and Rump, 2015).
- Teaching should be based on student activities (Biggs and Tang, 2007; Jørgensen, 2015).
- Content overload leads to surface learning. Therefore, sessions should not be overloaded with content in order to allow for deep learning rather than focus on content logic (Jørgensen, 2015).
- The session should be based on questions and key points with relevant models of understanding (Bligh, 2000).

The didactical contract

Guy Brousseau introduced the Theory of Didactical Situations (Brousseau, 1997; Brousseau and Warfield, 2015). Brousseau introduced a didactical contract that contains in essence two parts:

1. A contract of devolution - the teacher organizes and explains a student activity. The students' part of the contract is to commit him- or herself to the activity.
2. A contract of institutionalization – students propose their results and the teacher vouches for the part of their results that conforms to reference knowledge. The teacher connects the new experience with existing knowledge which is useful to solve similar other problems (Brousseau, Sarrazy, and Novotná, 2014).

Variation of teaching methods

Adding a diversity of teaching methods improves the learning outcome of students (Fry, Ketteridge, and Marshall, 2008). Thus, my aim to add several teaching and learning activities to the session in addition to the lectures.

Microscopy: Microscopy was added because it provides the students with a change of focus from their computer or the lecture screen towards the actual organisms that this session was about (Harley, 2004). The use of microscopes gives also a break from listening and provides some practical challenges for the students. For example to get the perfect light conditions, focus plane and the right magnification in place. Microscopy gives a quick motivation for the students to engage in the teaching and it provides an ignition for student teacher interactions on a more personal relaxed level. It gives the students an immediate idea of size and the amount of organisms in a certain volume of seawater. It is also important for the students to experience variation in sample quality, which is usually not shown when using optimal pictures to illustrate certain points in lectures.

Student experiment, experiment analysis and presentation of experiment results: The student experiment was planned because teaching based on student activities supports learning and involves the students more into the session (Biggs and Tang, 2007; Jørgensen, 2015). The experiment makes it possible to improve the amount of physical and psychological energy that the students devote to the academic experience (Astin, 1999). The aim was to increase the students' vigilance and to really draw their attention to the subject matter. This was further accomplished by the circumstance that the students had to present the results of their experiment to their peers at the end of the session, which usually motivates them. The experiments have practically illustrated the knowledge that was transmitted in the lecture just before the experiment, so that the experiments have been an extension to the lecture.

The session

All the above points were considered when planning the session with the aim to facilitate deep learning. Thus, the total amount of content was reduced as much as possible and the important points of the lecture illustrated by examples and by an experiment conducted by the students.

I started the lecture with a short introduction, devolution of the course day and a devolution of the experiments the students were going to do. Then

the students had time to set up the experiments, which was to measure the effect of toxic and non-toxic unicellular algal strains on *Artemia nauplii*. The students divided themselves into four teams. A positive control team with healthy non-toxic algae, a negative control team without algae, a treatment team with toxic algae, and a treatment team with toxic algae that not always produce toxins. As it takes some time to measure an effect of toxic algae on crustaceans the set-up of the experiment were set at the beginning of the session.

The experiment set-up was followed by a lecture about animal plant interactions in the marine environment were the important concepts and organisms were introduced. To look at the organisms covered in the lecture and to give the students some hands-on experience, the lecture was followed by devolution of microscopy. The students had first a little break and then time to look at the organisms in the microscope. As expected this exercise was also used to talk about the topics that were covered in the lecture and to talk about the organisms that were investigated with the microscopes. The microscopy exercise was followed by institutionalization of microscopy.

Next, we had another lecture with more complex plant animal interactions providing all the information the students needed to understand and analyze their experiments. Here they could already see what they were expected to conclude from their experiments. The students had then time to look at their experiments, and analyze the data they gathered. The students presented the findings of their experiments to the group, and the experiments were institutionalized. Finally, the session ended with a summary and conclusion part including the institutionalization of the course day.

Results

Students filled out a questionnaire immediately after the session (Appendix A). It contained general questions about their learning, questions about the course, and more specific questions about the session. Eight out of eight students answered the questionnaire. All students were master students and thus at the right competence level for the course.

The session material was made available for download in the online teaching platform ‘Absalon’ prior to the course day. 50% of the students have had a look at this material prior to the course. The intended learning outcomes have been quite clear to the students (five stated it was clear to an extend of 51-75% and three rated it clear within 76-100

When it comes to learning, the student feedback has been quite diverse. Six students considered lectures in general most beneficial for their learning, followed by practical exercises (five students), reading at home and watching educational movies (three students each).

As for the teaching and learning activities in the session, the students found the lectures most effective for their learning (seven said it to be 76%-100%). Microscopy and experiment set up has been conceived as less effective (five students scored it to be less than 50% effective and three above 50% effective). The analysis of the experiment has been conceived as little effective (25%-50%) by two students and above 50% effective by six students.

The amount of content as well as the difficulty of content during the session was rated good by all students who gave a rating on these questions (seven). The session in general has been rated as good (seven) or excellent (one).

Discussion and Conclusion

The results are based on a small sample with eight students participating in the course and answering the questionnaire. Still it is possible to conclude that students are very diverse in their needs, structure, and learning approaches. There will thus rarely be one single teaching or learning activity that works perfect for all students. This said, I argue the most important finding from my experiment is that students want and need diversity and variation in teaching in order to support their learning.

When it comes to learning, the student feedback has been quite diverse. Most students found the lectures to be most efficient for their learning and the practical teaching learning activities less so. These results may be surprising as the introductory remarks advocate for practical activities during teaching, but they make sense in light of the intended learning outcomes, which focused on the acquisition of knowledge.

As stated in the background information, lectures have been found to be relatively ineffective for goals of teaching that go beyond the transmission of information. The questionnaire however, did focus on learning in general, which I assume, the students who answered the questionnaire, considered exactly to be the transmission and reception of knowledge. Thus, the students could not learn anything about the complexity of marine food webs by looking at single celled organisms under a microscope.

However, they could learn aspects beyond the transmission of information, which have not been made explicit to them during the session or within the questionnaire. Two examples:

1. By microscopy, they learned that it is very difficult to directly observe small scale algae-animal interactions in marine environments, which can be quite frustrating after seeing nice movies and pictures of exactly those interactions during the lecture.
2. Through the analysis of the experiment they learned that it is possible to find unpredicted and new interactions as soon as one sets up species specific experiments.

From the results of the questionnaire, I can conclude that

1. Students preferences on how to learn are different and diverse. Teaching and learning activities that work well for some students might be less effective for others.
2. Variation and diversity in teaching methods will increase the overall student learning outcome.
3. Teaching and learning activities need to be well aligned to the intended learning outcomes.
4. Learning goals that are beyond transmission of knowledge need to be explicit in a questionnaire in order to evaluate them through student questionnaires.

References

Astin, A. W. (1999). Student involvement: a developmental theory for higher education. *Journal of college student personnel*, *40*(5), 518–529.

Biggs, J. & Tang, C. (2007). *Teaching for quality learning at university* (3rd ed.). Open University Press/McGraw Hill.

Bligh, D. A. (2000). *What's the use of lectures?* Jossey-Bass.

Brousseau, G. (1997). *Theory of didactical situations in mathematics*. Kluwer Academic.

Brousseau, G., Sarrazy, B., & Novotná, J. (2014). Didactic contract in mathematics education. In *Encyclopedia of mathematics education* (pp. 153–159). Springer.

Brousseau, G. & Warfield, V. (2015). Didactical contract and the teaching and learning of science. *Encyclopedia of Science Education*, 316–321.

Fry, H., Ketteridge, S., & Marshall, S. (2008). *A handbook for teaching and learning in higher education: enhancing academic practice*. Routledge.

Gundem, B. B. & Hopmann, S. (2002). *Didaktik and/or curriculum: an international dialogue*. Peter Lang Pub Incorporated.

Harley, J. P. (2004). *Laboratory exercises in microbiology*. McGraw-Hill Science, Engineering & Mathematics.

Jørgensen, P. S. (2015). Session planning. In L. Rienecker, P. S. Jørgensen, J. Dolin, & G. H. Ingerslev (Eds.), *University teaching and learning* (1st ed., pp. 149–164). Samfundslitteratur.

Mørcke, A. M. & Rump, C. Ø. (2015). University teaching and learning - models and concepts. In L. Rienecker, P. S. Jørgensen, J. Dolin, & G. H. Ingerslev (Eds.), *University teaching and learning* (1st ed., pp. 94–99). Samfundslitteratur.

Sølberg, J. (2015). Developing your own teaching. In L. Rienecker, P. S. Jørgensen, J. Dolin, & G. H. Ingerslev (Eds.), *University teaching and learning* (1st ed., pp. 251–257). Samfundslitteratur.

Weimer, M. (1990). *Improving college teaching: strategies for developing instructional effectiveness. the jossey-bass higher education series.* ERIC.

A Questionnaire:

Student answers are included in grey.

Plant animal interactions in the marine environment 09/2016				
How much of the material provided for the course today did you read before today's lecture?	0 - 25% 4	26-50% 2	51-75% 1	76-100% 1
To what extend is it clear to you what you were intended to learn today?	0-25%	26-50%	51-75% 5	76-100% 3
Which of the following activities do you in general consider most beneficial for your learning?	Lectures 6	Reading at home 3	Practical exercises 5	Watching educational movies 3
To what extend have the activities in this session been effective for you to learn the session's content?	Lectures	Microscopy	Set up of the experiment	Analysis of the experiment
(Please choose one percentage per activity)	0-25% 26-50% 51-75% 1 76-100% 7	0-25% 1 26-50% 4 51-75% 2 76-100% 1	0-25% 2 26-50% 3 51-75% 2 76-100% 1	0-25% 26-50% 2 51-75% 4 76-100% 2
How do you rate the amount of content in this session?	Too little	Good 7	Too high	
How do you rate the difficulty of this session?	Too low	Good 8	Too high	
How do you rate the session's material?	Poor	Satisfactory 1	Good 6	Excellent
How do you rate the quality of teaching in this session?	Poor	Satisfactory	Good 7	Excellent 1
Do you have any comments on how this session could be improved?				

B Structure of the session and intended learning outcomes:

Teaching was based on my own research on mixotrophy and the evolution of acquired phototrophy in marine unicellular organisms. This research gives a perfect example of the complexity involved in plant-animal interactions in marine environments. In crude terms, plants in the marine environment are algae, and algae - animal interactions are often difficult to define. One difficulty is, for example, the impossibility to decide if a cell counts as algae or animal as it might have a chloroplast only temporarily in its life cycle. The types of algae animal interactions in marine environments can be categorized as follows:

1. Classical food web: algae get eaten by animals.
2. Classical food web: algae avoid being eaten by use of toxins and/or morphological adaptations.

3. Permanent symbioses between algae and animals.
4. Non-permanent symbioses between algae and animals.
5. Inverse food web. Algae that eat animals
6. Inverse food web. Algae toxins that kill animals

Intended learning outcomes

By the end of this session, students will have a deep understanding of the complexity of marine food webs and plant animal interactions in marine environments. Students will be able to use microscopes and plan and execute small scale experiments. They can explain what makes the marine setting so special in comparison to terrestrial environments, which are covered in other sessions of the course.

The following themes were covered in the session:

- Plants in a marine context are algae -> types of algae
- Distribution and diversity of algae
- Magnitude of biomass and worlds net primary production by algae
- Chemical signals and toxins
- Algae-animal interactions, food webs in the marine environment
- Endosymbiosis
- Trophic modes

Teaching and learning activities

- Lectures
- Movies
- Experiment set up
- Use of microscopes
- Experiment analysis and presentation of results

Structure of the session:

1. Short introduction and lecture (+ devolution of experiments) - 10 minutes
2. Set up of experiments – 30 minutes
3. Lecture – 45 minutes (with 5 minutes break after 30 minutes)
4. Looking at organisms with the microscopes (including devolution and institutionalization of microscopy) – 30 minutes

5. Lecture – 20 minutes
6. Analysis of experiments – 20 minutes
7. Student presentation of experiment results (+ institutionalization of experiments) – 20 minutes
8. Summary and conclusion – 5 minutes