This is number one and two in the eighth volume in a series of publications of educational development projects made by participants in the teacher development course for assistant professors and post-docs held by the Department of Science Education, University of Copenhagen.

The aim of the series is to provide insight into the kinds of educational tasks and problems new teachers are facing, and to show how they manage them in inspiring ways.

University of Copenhagen

Improving University Science Teaching and Learning – Pedagogical Projects 2015, vol. 8, no. 1-2

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Preface

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This is the eighth volume of the Department of Science Education's series of pedagogical projects made in relation to the Higher Education Teaching and Learning programme at the University of Copenhagen. Since its inception, almost 200 participants in the course have chosen have their final development project in the course published in this series (198 to be exact!).

The series is published both in hard-copy versions and electronically, and can be downloaded from the webpage of the Department of Science Education.

Who are the main readers of the articles in the anthologies? There are several different target groups. The Department of Science Education certainly benefits from being able to showcase outcomes of the Higher Education Teaching and Learning Programme both to researchers in higher education research, and internally at the university. The authors themselves, of course, use the anthology to present their work – for instance by including their chapters in their individual teaching portfolios as examples of their development work. Most importantly, however, the anthology is being used as a common 'knowledge pool' for participants in the course embarking upon their own development work, and former participants in the course who seek information on specific topics. Where can one find, e.g. information on using thematic assignments in the quarter structure used at the Science Faculty? Or on how to make pre-lab exercises for student to prepare them better for lab work? Or how to develop cases that relate to specific research areas, and how to bring them into teaching? Or how to ensure coherence between overall programme objectives and the teaching and learning activities in specific courses in a Danish context? Or how to, as a course leader, organize a group of teachers so that they work towards a common goal? How can I organize large class teaching in interactive ways? Many of these questions have really thoughtful and good answers in the anthologies – answers that may be particularly fruitful because they are context-specific rather than general.

In the first few years of the series' existence, it was possible for the course teachers to have a relatively complete overview of the projects made. With time, and as the number of course participants and number of teachers have grown, this have become increasingly difficult. Although the electronic versions of the texts are searchable it is not yet easy to make searches across the many different volumes. At the Department we are considering how we can make the anthologies searchable in the future, so that the knowledge collected in the anthologies may become even more useful to an broader group of teachers.

The current volume has a high number of contributions, and, as a new trend, many of them concern the organisation of laboratory work for better learning outcomes. It is worth wondering why the interest in laboratory work is apparently on the rise. A simple explanation is perhaps that the biological and chemical subjects, including many subjects within the health sciences, have become more prominent in the professions represented in the courses and that the topics has been given increased emphasis in the course. Another reason may be that in times of sparse resources it is becoming increasingly important to justify the role played by costly teaching formats. A third reason is that while the value of laboratory work for students is readily recognized by anyone working in the chemical and biological sciences, it is also clear that learning outcomes can be improved and that new forms of assessment may be needed. The present volume touches upon such topics as how to engage students in research or research like activities through laboratory work, how to scaffold students' learning prior to lab work to prepare them better for their time in the lab, and poses relevant questions concerning the replacement of laboratory work with virtual experiments.

Other contributions concern the special challenges posed by interdisciplinary teaching – dealing with both teacher and student perspectives, course redesign, using ICT tools to promote learning, scientific reading and writing, and a number of contributions focus – in different ways – on how to promote deep approaches to learning in various subject.

We would like to thank all of the authors for their valuable contributions to the promotion of Scholarship of Teaching and Learning at the University of Copenhagen.

Part I

Improving students' outcome of laboratory work

1

Does instruction video increase the learning outcome from laboratory exercises?

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Introduction

Laboratory exercises are included in many courses in the BSc and MSc programs at the Faculty of Science. The laboratory exercises aim to develop the practical skills of the students, but obviously the practical experience also contributes to the attainment of theoretical knowledge. The laboratory exercises at the BSc level are commonly fixed exercises, where the students have to follow a given protocol or manual prepared by the teacher or researcher. Experience tells us that if the students read the protocols, they often do it in a cross reading manner and not as thoroughly as we would like them to.

The technological development eases the accessibility of different media, such as smart phones, tablets, laptops etc., so the question to be asked is whether the use of instruction videos may increase the students preparation for and understanding of the practical laboratory exercises.

In order to investigate the use of instruction video, videos were prepared for three exercises from three different courses, namely Experimental soil analysis (ESA), Biochemistry, and Food Chemistry. In ESA especially one exercise is known by experience to take much longer time than the other exercises and leave less time for discussion of the theory, reflection on results and perspectives during the exercise. Hence, the teacher in this exercise feel a need for much better student preparation, in order to reduce the stress for the students and teachers. The Biochemistry course is attended by second year students, which do not have much experience in the laboratory. Therefore, reading the laboratory protocol can be challenging and confusing to them, since they may not know many of the typical laboratory phrases/instrument names. Our experience is that the students often spend time reading the theoretical introduction to the exercise, but generally they did not spend much time on reading the part dealing with the practical work. Pre-laboratory questions are included with the aim of helping the students to get an understanding of the purpose of the exercise, and also to give them "tools" so they would easier understand how to solve different problems during the report preparation. In Food chemistry, the teachers often experience that the students does not understand certain parts of the laboratory-protocols and errors and mistakes, which cannot be corrected due to limited time, occurs. Hence, instruction videos, even though they only provide information which is already given in the protocol, may avoid a lot of mistakes during the exercise and optimize the time spend in the laboratory, both for students and teachers. The videos are designed to be a supplement to the protocol, and should thus not replace either the protocol or the actual practical exercise.

The overall aim of the present report was to evaluate whether instruction videos increase the learning outcome, both practical and theoretical skills, from laboratory exercises. This was investigated by exploiting the three hypotheses:

- The students are better prepared when entering the laboratory
- The teachers' workload is reduced
- The students' impression is that learning outcome (practical and theoretical) of the practical exercise increase

In order to be able to verify or reject the hypothesis, this report includes a brief introduction to some of the theoretical concepts related to learning and the use of instruction videos in teaching, as well as the results gained through questionnaires completed by the students attending the three courses, EAS, Biochemistry, or Food Chemistry. As the study was conducted on three different courses with very different number of students it was chosen to do the same quantitative and qualitative questionnaire at all three courses (Appendix A). Furthermore, the teachers of the exercises where interviewed regarding their experience on teaching with videos. The results of the three parts lead to a general discussion, as well as a conclusion and some perspectives.

Theory

Pedagogical theory on cognitive learning

Learning has been described by Piaget as a cognitive adaption process, were two opposite directed part processes takes place; i) the assimilation, where new experiences are adapted into the existing knowledge (the existing scheme), and ii) the accommodation, which constructs and develops new cognitive structures, so they fit into a new changed scheme (www.blivklog.dk). The two parts takes place concomitantly in a dynamic process, a state of equilibrium.

Similarly, Illeris (2007) describes four types of learning; i) cumulative, ii) assimilative, iii) accommodative, and iv) transformative. Cumulative refers to the learning where the new experiences do not fit into any existing scheme. Assimilative is, as described by Piaget, when new knowledge can fit into an existing scheme. Accommodative is when new experience extends, adjust, or reconstruct an existing scheme. Transformative means the concomitant reconstruction of multiple schemes.

Learning situations, competence stages and the use of instruction videos

Illeris (2007) also describes situated learning as the combination of two situations; i) the immediate situation where the learning takes place, and ii) the societal background or framework in which the situation enters into. For the immediate situation the laboratory exercises contributes to the immediate learning gained by the student, and for the societal aspect, the practical exercises contribute to the development of competences, which are essential for the student as a future employee, their organizations, companies, and the nation competitive position. There are massive societal interests in optimizing learning, and herein the acquisition of practical skills (Illeris 2007).

In order to gain new insight or new experience a disturbance is essential, and the art in teaching is to create the appropriate disturbance. It should not be too big and not too small. According to the theory of Dreyfus & Dreyfus (1980) and Illeris (2007), the chaos should be minimized for the unexperienced student. This also applies for a laboratory exercise. The level of disturbance must be appropriate, and sometime the gap between the protocol and the practical execution in the laboratory may be too big a disturbance, where an instruction video may act as a buffer to adjust the disturbance to the correct level. The nature of this disturbance/chaos should be aimed at the understanding, or perspectives rather than confusion about the experimental work. Hence, the idea of introducing instruction video is to minimize the chaos related to the practical work, so that focus can be related to the theoretical understanding.

Likewise, the five-staged model proposed by Dreyfus & Dreyfus (1980), describes the need for strict guidelines for the student in the beginning in order to acquire skills. These five stages are divided into; novice, competence, proficiency, expertise and mastery. In order to move from the novice level to the mastery level concrete experience is needed, and it is important to design material for the student based on which level the student is. The novice has no experience and needs to have rules and be instructed in order to learn, and on this stage the task is learned in a context-free environment. The competence is acquired, after considerable experience with real situations, and the student is no longer working in a context-free environment. In the proficiency level the student has experience from many different situations, and has reached a level where he/she is able to recognize this type of situation viewed from a similar perspective. The expertise level is reached when the student has reached the stage where he/she, is able to reflect about what she/he is doing. The final stage, the mastery, the students has reached a level of expertise, where he/she no longer relies on rules, or guidelines, and is able to absorb from his own performance and find appropriate perspectives and actions.

In these laboratory courses we consider the students to be at the novice and competence levels. So here the students need specific guidelines and instructions, as well as repetitions of experiments. The videos made in this project, is thus meant to be a part of the instructions that the students need in order to move from the novice level to the competence level. The complete guidance of the students in the laboratory should decrease the chaos, if there are too many new elements it will become overwhelming for the students and nothing will be gained. At first the students need to follow strict guidelines, in order to be familiar with the different types of techniques, but these guidelines need to be coupled to an understanding in order to improve the performance and student motivation (Dreyfus 2004).

Teaching and learning using various media

Many different types of media that can be used to communicate teaching exist, and among these are; face-to-face communication, text and pictures, videos and film, computer software, and networks. Each media has benefits and disadvantages, and it is important to recognize which teaching situating the media is best suited for (Collins et al. 2000). Moreover, it is important to recognize new technology, rather than only sticking to the old classical way of teaching.

Using video is an excellent tool for visual learners, and the advantage of the video, is that the student can watch it anytime at the location of choice, and that they can repeat the video several times. Three different types of video genres exist, live action, animation and talking heads. The live action video gives the possibility for the student to see and recognize object/ full process. Talking heads may be used to make the producer (teacher) visible. Animation may give a better understanding, than if a picture is shown in a text book. Moreover, the video may preferable be combined with a speaker, which explain what is happening, at the same time it is shown (Collins et al. 2000).

The disadvantages with videos are that they are time consuming to produce, but once produced they can be used many times. Another challenge is how to make video that promotes the understanding, which deals with the type of illustrations/learning events added in the video.

Experimental soil analysis (ESA) instruction video

The ESA course is a first time running optional BSc course. Eight 3th year students from Natural Resources and Geography attended the course this fall. They do not have much experience in the soil physical laboratory, which contrarily to many other laboratories do not include many pipettes or solutions. However, this course is still more on how to comment/explain/elaborate on the results obtained than on how to do experiments in the laboratory.

Materials and methods

In this course the 8 min and 30 sec long live action instruction video with speak was made with Windows Movie Maker. The specific exercise

"Soil texture and soil classification" had 4 sub exercises, but the video only showed the 2 main sub exercises. The teacher responsible for the exercise showed each step of the laboratory exercise, alongside she was telling why she did what she did, mentioning the physical laws which allowed her to do what she did, and showing the equipment to be used. The video was uploaded to Absalon and the students were asked face to face to see it. However, problems with downloading the video occurred, so not everybody had the chance to see it. Three students saw it beforehand on their own, 3 was forced by the instructor to see it, and 2 students saw it afterwards.

The soil physic exercises are taught in a rotation manner so the groups (2-3 persons) do different exercises at the same laboratory week. The actual laboratory work was conducted Monday afternoon, whereas they had supervision time on the reports Wednesday afternoon; here each student answered the questionnaire (Appendix A) about the use of instruction videos.

The teacher was asked to note whether the students were more prepared than previously. However, it should be noted that her answers can be biased as the manual was rewritten and optimized before this course, and one group also had access to pre-laboratory consideration/questions do to a result of a midterm evaluation.

Results

Do the students want to watch the video?

All students replied positively that they wanted to see instruction videos in the future. Seven out of 8 would like it to be on the practical part of the exercise – as many of them stated in different words that the instruction video had given them an overview over the exercise, and removed the visualization barrier so it was easier to focus on why they did what they did, and not solely on how to do each step in the manual. Six out of 8 of the students could see a potential in instruction videos with specific theory on some of the other exercises, which was more abstract than the examined exercise. Only 1 student wanted the video to include report issues and 1 student would like some perspectives in relation with the learning outcome of the course.

Five out of 8 students (not the same persons) marked that the subject, the quality of the video and the length of the video was important when they decided on watching instruction video in general. Those students who elaborated on this wrote that the video should not be too long – whatever that is.

Even though they were very positive about watching instruction videos 5 out of 8 did not manage to see it beforehand. The dominating reason (3 students) for not watching the video was problems with downloading the video from Absalon, one argued she did not have time, and one wrote that even though she was asked to watch it and knew it was important for this project, she forgot to do it.

Preparation time

Of the student who had seen the video beforehand (on their own and forced) 3 had used less time and 3 had used the same amount of time compared to the other exercises. They had used between 35 min and 120 minutes to prepare, and the one with preparation of 35 min had seen video beforehand.

How were the students' understanding of this exercise compared with the other exercises?

In general all participants felt that the video had increased their understanding of the exercise. Their arguments are given below in table 1.1.

When do the students feel they understand the purpose of the exercise and feel they have an overview of the exercise?

In ESA 3 students answered "after the experimental work", 2 answered "after the experimental work" or "during the reporting part" depending on the topic, 2 answered "during the reporting part" whereas 1 forgot to mark. Of those who saw the video, 3 answered that the video had change when they felt they understood the purpose of the exercises, as they understood why they were doing what they were doing, and therefore could focus on understanding. The other 3 said both yes and no as they argued that they had a much better overview of the exercise. However, the bigger perspective on why the exercise theme was important was understood when they wrote the report.

Note on the teachers' experience

The video had not helped shortening the time used for conducting the exercise. But the instructor pointed out that she had spent her time differently

Table 1.1. The students understanding of the instruction video exercise compared with other exercises. Person 1 and 2 saw the video afterwards. The statements are translated from Danish

1	Saw the video after the exercise, but it still helped as you can see how the various things is to be done and not just that they have to be done as the written manual often states.
2	The understanding of this exercise was good because I knew the theory from previously courses. Fine exercise instructions, although it was messy in the description of the exact execution.
3	The video was very clear and easier to relate to than written instructions as you see what happens.
4	Increased understanding! I have both read the instructions and watched the film. Watching the process as well as seeing the materials and equipment provided both better understanding and facilitate a better exercise execution.
5	The substance was easier to understand, but as I used less preparation time than normally, I was confused about the content of the exercise when entering the laboratory as it was confusing with the many sub exercises.
6	Too bad that there was only an instruction video for one part of the exercise – I still think that the part with the pycnometer was difficult.
7	Good, mostly because we were split up so one would make one part of the exercise and the other where doing other parts. I did not do the video part but it helped me to understand what had been done.
8	It was nice to have the possibility to see the instruments, it was a little demystified. It kept my attention on the things you read in the manual and heard during the exercise and on the things you should be aware of. Overall it was much better with the video.

than she was used to. Previously she used most of the exercise time on answering especially technical questions, but this year she spend more time on asking questions in regards to why the students they did what they did and on discussing what the result could be used for in a broader perspective ect.

Biochemistry instruction video

Materials and methods

In this course the instruction video was made with Screencast-o-matic, which is a power point slide show with a speaking voice added (animation video with speak). The video was send by email through Absalon to the students 1-2 days before they had the exercise.

The biochemistry laboratory exercise course covers 6 different laboratory exercises. Each exercise in the course is run 10 times during two weeks with 247 students in total and with 24 students each day. The instruction video was prepared for the exercise;“ Enzymkinetik, β-fructosidase fra gær", and given to students at two different exercise days. At the end of the exercise, each student had to answer the questionnaire (Appendix A). The two teachers attending the exercises noted at which time the students started each of 4 parts within the exercise, and the laboratory teachers were asked to answer the following questions:

- Are there less mistakes/confusion during the exercises in the teams who have seen the videos compared with the teams who have not?
- Do you generally notice any difference between the teams which have seen the video and the teams which has not?

Results

Do the students want to watch the video?

On day 1 (Thursday afternoon) 62% of the student had watched the instruction video which they received Monday morning by mail. In order to increase the number of students having watched the video, the video was send by mail Wednesday morning to the students having laboratory work Friday morning (day 2). However this did not improve the number of student having watched the video, in fact most of the students from the second day (Friday) showed up in the laboratory without having watched the video. The laboratory teachers encouraged the students to watch the video at the end of the experiment, and then give their opinion of the video by filling out the questionnaire. This encouragement from the laboratory teachers lead to an increase in students who had watched the video, but at the end of the day only 50% of the student did manage to watch it. The group of students which did not watch the video was then used as a control group.

The way the video is distributed seems to be a big issue. The reason for not watching the video was for most part of the students that they did not check their Absalon mail and thus was not aware of the existence of the video. Some also answered that they simply forgot to watch it, only a few students argued that they were not interested in watching a video. However, all the students did state that they think inclusion of instruction videos in other courses would be a good idea. The majority wanted the instruction videos to deal with the practical part of the experiment and specific theory, but there were also a great deal of the students who would like the instruction videos to handle the reporting part as well as perspectives.

Preparation time

Independent of having watched the video or not, then the students had spent less time spend on preparing for this particular exercise compared with other laboratory exercises in the biochemistry course. The main reason for this was according to the student that the laboratory protocol easier to read and more understandable. A few students also answered that this topic (enzymes) is their favorite topic.

How were the students' understanding of this exercise compared with the other exercises?

All the students who had watched the video felt they had a better understanding, and stated that it was because of the video. On the other hand, some of the students who did not watch the video also felt that they had a better understanding (22-25%) or a good understanding (44-50%) and 25-33% of these students felt their understanding of the exercise was similar to the understanding they had in other exercises (Table 1.2).

Table 1.2. The student' understanding of the instruction video exercise compared with other exercises.

	Video	Better	Fine	Similar
Tuesday	Yes	100%	0	0
	No	25%	50%	25%
Friday	Yes	67%	25%	8%
	No	22%	44%	33%

When do the students feel they understand the purpose of the exercise and feel they have an overview of the exercise?

The majority state that they get the overview after doing the reporting part. Interestingly, the most of the students who have watched the video, answered that they get this understanding already after having made the experimental part of the exercise (Figure 1.1).

Note on the teachers' experience

The teachers found the laboratory was calmer on the Tuesday where 62% had watched the video, and they experienced less questions and different

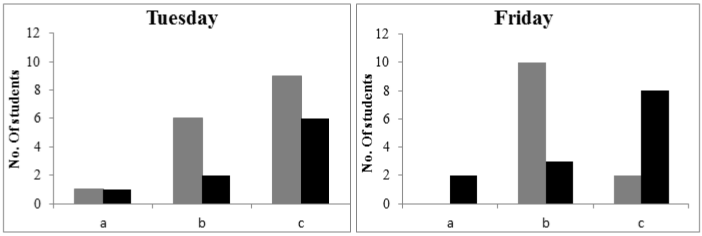

Fig. 1.1. Student answers to the question; When do you usually feel you have an understanding and an overview of what the exercise is about" A: After having read the protocol; B. After having made the experimental work; C. During the reporting part. Gray: Did watch the video, Black: did not watch the video.

types of questions, compared with the other days, showing that the students were less confused about the exercise.

The teacher noted at which time the students started with each of the individual tasks in the exercise, but there were no difference in time when compared with the other 8 days where the exercise was running in the laboratory, and thus, the instruction video had no effect on the amount of time used in the laboratory.

Food chemistry instruction video

The food chemistry course in mandatory for second year students enrolled in the Food Science and Technology programme. This is one of the first courses the student attend where food products is the main focus, and at this point the students have obtained some experience in the laboratory during their previous courses, e.g. Biochemistry mentioned above. The intended learning outcome from the laboratory exercises in this course is i) to be able to work in a laboratory with selected experimental techniques and methods used to examine and evaluate food and food products, and ii) to analyze and disseminate own experimental results. Here the students are at a level, where they from their experience e.g. in Biochemistry are expected to know how the basic laboratory equipment works. However, in Food Chemistry they will still meet new types of experiments, equipment, apparatus, and other types of analyses.

Materials and methods

The practical part of Food chemistry consists of 4 laboratory exercises conducted within 4 weeks. Exercise 1-2 in week 1 and 2, and exercise 3-4 in week 3 and 4. The approximate hundred students are paired and distributed in teams which perform the exercise either Monday (16 students), Tuesday (32 students), Wednesday (16 students) or Thursday (32 students). For exercise 3 “Lysinducerede oxidative ændringer i mælk og forsæbning af mælkefedt” in Food chemistry, an instruction video of 15 minutes duration was prepared and uploaded to Absalon in week 2, and reminders to watch the video were sent by email through Absalon to the students the day before they were going to perform the exercise. As it appeared that the students had problems downloading the video, it was launched in the end of week 3 on www.youtube.com (http://youtu.be/lXFiiba_89A) and on the Department of Food Science web-page (http://food.ku.dk/uddannelse/bsc_msc/). The video was prepared in Windows power point, Windows Movie Maker, and Screencast-o-matic with voice-over added (mixed live action and animation video with speak). The exercise consisted of four parts which were recorded individually and the combined into one video including:

- Introduction in power point summing up the basic theoretical background, safety issues, and purpose of the exercise.
- Video showing the four parts of the exercise.
- Remark on how to organize the time spend in the laboratory.
- Description of pre-laboratory exercise.

At the end of the exercise, each student were asked to fill in the questionnaire (Appendix A).

Results

Do the students want to watch the video?

Of the 96 students attending the practical exercises in Food Chemistry, 67 filled in the questionnaire after carrying out exercise 3. Of the 67 students, 81% had seen the entire instruction video before the exercise. The remaining 19% had not seen the video due to technical problems with downloading the video, and a few complained about the video being too lengthy.

Preparation time

In average the student had spent 45 minutes preparing for the exercise, where they normally spend in average 44 minutes for laboratory exercises.

How were the students' understanding of this exercise compared with the other exercises?

The students were asked how the understanding of the content and execution of the exercise was compared to other exercises in the same course, and the majority (75%) clearly felt that the understanding was higher compared to other exercises due to the instruction video. The students felt that having seen the instruments and apparatus helped them feel more comfortable and secure when performing the exercise.

> *"Meget bedre! Jeg vidste hvordan tingene (udstyr, maskiner) så ud, og hvordan tingene skulle udføres."*

When asked if there were other things that may have affected the understanding obtained, the majority pointed that the quality of the manual had influenced the overall understanding (Figure 1.2). However, the students did not agree on whether the manual was of good or bad quality.

> *"God udførlig manual"*
> *"Manualen var ikke særlig god. Meget i tvivl om udførsel af eksp. arb. + spm. − hvad er det præcist vi skal svare på."*

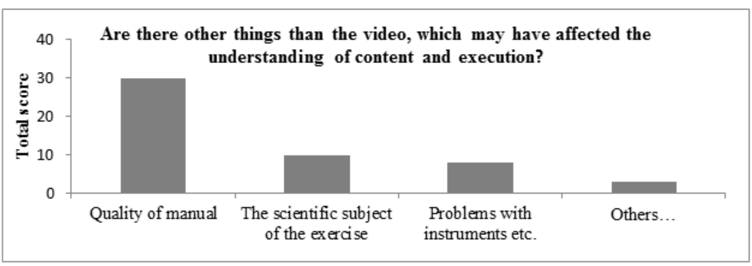

Fig. 1.2. Total scores to the question: "Are there other things than the video, which may have affected the understanding of content and execution?"

When do the students feel they understand the purpose of the exercise and feel they have an overview of the exercise?

When asked when the students normally obtain overview and understanding of the exercise, most students replied either after executing the experimental work or during the report writing (Figure 1.3).

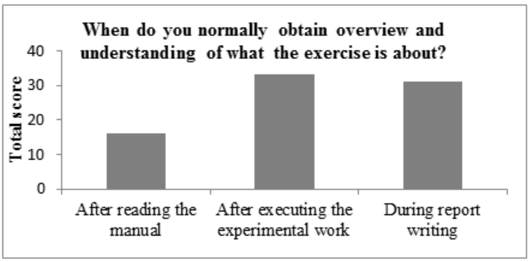

Fig. 1.3. Total scores to the question: “When do you normally obtain overview and understanding of what the exercise is about?”

After using the instruction video for the preparation, this had changed for 66% of the students. They felt that the video increased their knowledge by visualizing the practical part, but did not improve the knowledge obtained about the theoretical part.

> *“Video har hjulpet på den praktiske forståelse, altså udførslen af øvelsen.”*
> *“Kun i forhold til det eksperimentelle, ikke selve teorien.”*

When asked, what would make the students watch instruction videos for preparation of practical exercises in this course or other courses, the students replied that especially the quality of the video was essential, but also the subject, duration, and expectations from the teacher was of relevance (Figure 1.4).

Do the students feel that instruction video is a good format for preparation of laboratory exercises, and how may the format be further developed?

More than 92% of the students agreed that instruction videos would be a good idea for other exercises in the course, and they suggested that the

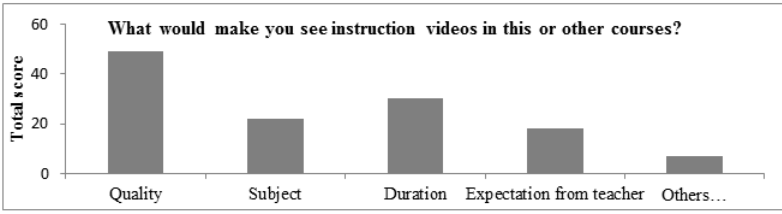

Fig. 1.4. Total scores to the question: "What would make you see instruction videos in this or other courses?"

development of the instruction video format should focus on especially the practical parts, but also the theory, data analysis, and perspectives (Figure 1.5).

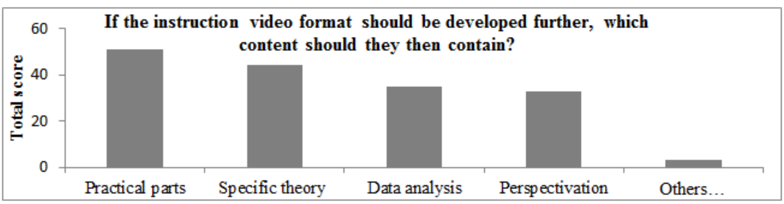

Fig. 1.5. Total scores to the question: "If the instruction video format should be developed further, which content should they then contain?"

Note on the teachers' experience

A small focus group interview with three teachers was carried out. The teachers did not observe that the students had finished earlier, or that fewer mistakes had occurred for those who had used the video as preparation. All in all it was very difficult for them to evaluate any effect of the instruction video.

General Discussion

Do the students want to watch the video

When asking the students if they would like to have more videos in the future, the majority of the students think it is a very good idea. However, not all of the students watched the video before attending the laboratory exercises. There were some technical difficulties, but a lot of the students replied that they simply forgot to watch it, or didn't watch it because it was too long, which witness a low motivation to watch the video. Since so few students watched the video in ESA and Biochemistry, another approach was used in Food Chemistry. Here the video was mentioned at lecture, where it was stressed how important it would be to watch the video, and also, the day prior to the exercise, the students were reminded by email about the video. This had some effect, since here 81% of students had watched the video before attending the laboratory exercise. The same pattern was seen in the Biochemistry course, where the video was mentioned to the students on the Tuesday team when they were in lab a week before the exercise, but the Friday team only received an email about the video. The result was that half of the students from the Tuesday team had watched the video, but almost nobody from the Friday team had.

It would be interesting as a follow-up of the present study to interview the students about their preparation habits, and how they decide on what and how to prepare for the individual parts of their courses. Such information could be extremely useful for the preparation of lab exercises and also other teaching activities.

Effect of the video on preparation time, and time spend on laboratory exercises

The student used less preparation time for the examined exercise in two of the courses. However, it cannot be concluded that it was because of the video, as the main reason might be easier readable protocols and understandable subjects. In the Food Chemistry exercise, the students had used the same amount of time for preparation as usually. However, visualization of the practical part of the exercise helped the students to get a better understanding of what was going to happen in the laboratory, and thus reduced the confusion they would otherwise have had when only reading the protocol.

There were no effect on the time spend on the practical part, as watching the video did not reduce the time in the laboratory. This was in part due to the fact that the students still need to acquire the practical skills by hands-on and repeated experimental work in order to achieve experience to reach the level of competence.

However, in the Biochemistry exercise less chaos was observed in the laboratory, the students were calmer, and it was clear that they had knowledge about how the laboratory exercise was build up and was less confused. The video helped to visualize the experiments, which is often difficult for students since they are not familiar with new methods. Furthermore, the teachers in both Biochemistry and ESA observed that the nature of questions asked had changed, and that students who had watched the video asked questions, which showed a deeper understand of the experiments, compared with students who did not watch the video, similar results were seen in the study by Nielsen & Eriksen (2014).

Effect of the video on gaining overview and understanding of the content of the exercise

In all courses the students felt that by watching the instruction video as a part of their preparation their understanding of the content and execution of the exercise had increased. Especially, seeing the instrument and apparatus before going in the laboratory made them feel more comfortable and secure when carrying out the exercise. In any situation of teaching it is important to consider which learning types the teaching activity relates to. Commonly teaching will be assimilative, but sometime there is a gap in order for the new experience to fit into an existing scheme (Illeris 2007). When the students read a laboratory protocol, they may be familiar with some of the concepts and techniques described, but many details will be unknown for them and difficult to imagine, when not having the laboratory experience. Using instruction video in the preparation for laboratory exercises may cover that gap partly, as the students are able to visualize the unknown techniques or instruments before actually performing the exercise. Another aspect is that students learn differently, and instruction video may catch the attention of student which learn better visually rather than by reading. The results of the present study also showed that the majority of students felt that they gained overview much sooner in the process when using the instruction video in their preparation. According to Dreyfus & Dreyfus (1980) the students need to move from novice to mastery by passing all the stages in between. This study shows that instruction video may facilitate this process and make the path through the at least the lower of the five stages easier.

Future use of instruction videos

From the quotes (e.g. Table 1.1) it was found that most students felt they learned from the videos. However, there are still a number of issues to be solved before instruction videos add significantly learning abilities to the didactic room in the laboratory. First of all if we do want to create a better learning environment allowing for more reflections on the subject taught the students should have easy access to the instruction videos create. There was a clear tendency in our data regarding the difficulties of getting knowledge about where to access the video (the students did not check their Absalon e-mail), they could not access the video because it was uploaded in a format which was not accessible to all devices or they just forgot to look at it even though it was an outspoken and clear demand from the teachers. The fact that it was far from everybody that saw the videos, will lessen the surplus of reflection the students could have gained if everybody had seen the video. Hence, in order to use instruction videos and get the most out of them some requirements should be met. The videos need to be of good quality, not too long, mainly but not solely focusing on the practical work and easy to access on any electronic device, as well as the students need to be motivated as discussed previously. Furthermore, it should be noted that if the intention with the videos are to create a flipped classroom environment the videos should also be mandatory to watch before entering the laboratory. A way to make the students watch the video could be to add a pre-lab quiz, as a set of questions in the pre-lab section, which can only be answered after having watched the video.

Nielsen & Eriksen (2014) successfully introduced a slightly alternative approach during an experiment which was conducted at the University College Sjælland. They added QR codes to the instruments in the laboratory and when the students scanned the codes, videos were accessible and the students could even add their own notes to the videos. The study showed that the use of instruction videos accessible in the laboratory for the students to see on either tablets or smart phones during the exercise increased the time for reflective discussion and dialog between students and teachers (Nielsen & Eriksen 2014). Hence, such system could be interesting to look more into as it overcome the problems that not all students has seen the videos beforehand.

Conclusion

The first hypothesis; that students are better prepared when entering the laboratory, could not be verified or rejected. There were other factors which had an effect on the students understanding, like improved laboratory manuals, and generally better understanding of the subject. But in all three courses, there was a tendency of improved understanding when the student had watch the video, as the students had concrete ideas about how the experimental work was to be carried out.

The second hypothesis; that the teachers' workload is reduced must be rejected as the teachers workload was not found to be reduced. But there was a tendency of improvement, since the nature of questions asked to the teachers witnessed of an improved understanding of the practical work. Without the instruction video, time was spend on *how to do*, while when the students had seen the video, the time was used for *discussions on why*.

The third hypothesis, that the students' impression is that the learning outcome (practical and theoretical) of the practical exercise increase, was verified as all the students who had seen the video answered that they had a better understanding of what was going to happen in the laboratory. Furthermore, it was the students' impression that they obtained the overview of the exercises during the practical part rather than during the writing of the report as for exercises without instruction videos.

Perspectives

In this study the effect on learning outcome was investigated on basis of the students own experience, and indirectly from the experience of the laboratory teachers. It would be interesting, to continue the studies and get a deeper insight into how the learning outcome has improved – by preparing an experiment where the students understanding was measured directly.

Furthermore, in the future we would work on the quality of the videos, for instance by asking the "it learning center" for help. This is a trivial task, but as the students ask for quality this might be important anyway. However, one should still remember that the video should not be more "perfect" than it is still possible to adjust it over the years. Another issue which should be approached is the classical question when working with flipped classroom – how do we get the student to view/do the pre-class preparation - so we as teachers do not have to repeat our self in the class but instead can be able to elaborate, discuss and increase the room of didactic when being together. In this study we found that even though many students would like to see more videos in the future, we as teachers must be able to motivate the students to not only saying that they would like to watch the videos, but actually watch them as they can be time consuming to produce. An answer to this could be small instruction videos “on site” in the laboratory for the students to see while performing the exercises, this may also free some instructor time, which then can be used for discussion instead.

A Spørgeskema angående brug af instruktions videoer i laboratorieundevisningen

1. Har du set hele videoen? Ja____ Nej_____
Hvis nej, hvorfor ikke:______________________________
____

2. Hvor lang tid brugte du på at forberede dig til øvelsen?
____

3. Hvor lang tid bruger du normalt på at forberede dig på laboratorie øvelser?
____

4 Hvordan har din forståelse af indholdet og udførslen af denne øvelse været i forhold til de andre øvelser i kurset? Begrund!
____
____

4A. Er der andre ting end videoen, der havde en indflydelse på det (sæt gerne flere kryds)?

a. Kvaliteten af manual
b. Øvelsens faglige emne
c. Problemer med instrumenter eller lignende
d. Andre ting
____

Begrund dine/dit kryds:
____
____

5. Hvornår opnår du normalt overblik over og en forståelse af hvad øvelsen går ud på:

a. Efter at have læst øvelsesmanualen
b. Efter at have udført det eksperimentelle arbejde
c. Under rapportskrivningen

Har videoen ændret på det?____ja______________nej______________

Hvordan?______________________________
____

6. Hvad vil få dig til at se instruktions videoer i dette kursus og på andre kurser:

a. Kvaliteten
b. Emnet
c. Længden
d. Forventninger fra underviseren
e. Andet

7. Kunne du forestille dig at instruktions videoer generelt ville være en hjælp til andre øvelser på kurset?
____
____

8. Hvis vi skulle udvikle instruktions video formatet, hvilket indhold skulle videoren have)

a. Praktisk udførsel af øvelsen
b. Specifik teori bag øvelsen
c. Efterbehandling af opnåede resultater
d. Perspektivering af øvelsen i relation til kursets læringsmål
e. Andet

<u>Skema til undervisere:</u>

Noter tid på hvornår holdende er færdige med deres øvelser?
Er der færre fejl ved udførsel for de hold der har set videoen?
Kan I generelt mærke forskel mellem de hold der har set videoen og de hold der ikke har?

2

Analysis of intended learning outcomes and evaluation of teaching activities in practical courses on microscopy

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Introduction

The cell and the processes taking place therein are at the center of today's biological science. Among the tools available to study cells, microscopy stands out, because it is the only technique that can make the micrometer- or nanometer- sized objects visible to the human eye. Therefore, microscopy training is an essential part of every study program within life and medical sciences. In recent years, there has been a trend to replace hands-on training using actual microscopes with "virtual microscopes" (Schwartz 2005), computer programs in which the function of a microscope is simulated. This has happened primarily at medical schools, but the high cost of the infrastructure that is needed for hands-on training also causes biology departments to consider switching to "virtual microscopes". It is therefore timely to investigate how microscopy techniques can be taught most efficiently.

In this study, different teaching activities (TAs) that are currently used for microscopy training of students will be assessed regarding their value for the realization of intended learning outcomes (ILOs). The first part aims to clarify whether there are differences between the ILOs of different microscopy courses taught at Danish Universities. Understanding differences in ILOs is a precondition for the general assessment of microscopy-related TAs. In the following part, the potential of virtual microscopy for microscopy-related courses will be assessed qualitatively by interviewing experienced lecturers. This part aims to advance the debate on which learning outcomes can be realized with "virtual microscopes". In the last part, the value of different teaching activities for realizing a course's ILOs from a student's perspective will be investigated. Course evaluations are used to find out which teaching activities are critical for the successful implementation of a practical course in microscopy.

Method

Analysis of intended learning outcomes of microscopy-centered courses

Course databases of all major Danish Universities were searched for microscopy-centered courses. Information on the ILOs was obtained from the course descriptions as found on the internet. The following courses were included in the analysis: "Electron microscopy" (*University of Copenhagen* 2014*a*), "Light microscopy - Advanced methods in microscopy" (*University of Copenhagen* 2014*b*), "Confocal laser scanning microscopy" (*University of Copenhagen* 2014*b*), "Scanning electron microscopy" (*University of Copenhagen* 2014*b*), "Electron microscopy and analysis for materials research" (*Technical University of Denmark* 2014*a*), "Ph.D. Summer School on Methods in Imaging and Energy Material Microstructure" (*Technical University of Denmark* 2014*b*), "Stereology" (*Aarhus University* 2014), "Nano-optik" (*Technical University of Denmark* 2014*c*), "Biophotonics" (*Technical University of Denmark* 2014*d*), "Principles Light and confocal microscopy" (*University of Denmark* 2014), "Molecular Biophysics – Fluorescence microscopy and surface-sensitive techniques" (*Center for Membrane Physics* 2014), "Fluorescennsteknikker for biomolekyler og celler" (*Southern University of Denmark* 2014).

All of the above courses are taught at graduate level. Undergraduate courses, even when they include teaching in practical microscopy do generally not address this skill in their ILOs, as they are only subject-focused. In order to get information on microscopy-related ILOs of undergraduate courses that include acquisition of microscopy skills, the teachers responsible for the course in question were asked.

Assessment of virtual microscopy

The viewpoints and comments of two experienced University lecturers working at the University of Copenhagen were considered. Prof. Alexander Schulz from the Faculty of Science teaches general cell biology courses for Bachelor students in biotechnology and veterinary sciences programs. Clinical Prof. Ben Vainer from the Faculty of Health Sciences teaches the introductory course in pathology for medicine Bachelor students.

Their experiences with and virtual microscopy and their opinions were collected from interviews and contributions to the University newspaper "Universitetsavisen" (Fjeldberg 2014, Vainer 2014, Schulz 2014).

Student evaluation of teaching activities

Relevant information was obtained from the anonymous evaluation sheets for the graduate-level course "Advanced Methods in Microscopy" for the years 2012, 2013 and 2014. Students attending the course have different study backgrounds, but the average competence level was similar in all years according to the responsible teachers. The students that participated in the course were asked to fill out the evaluation sheet on the last course day or within one week after completion of the course. The participation rate was 80% in 2012, 74% in 2013 and 75% in 2014. Between 16 and 20 students participated each year.

Results

The intended learning outcomes of microscopy courses differ in the degree of practical skills to be conveyed

Teaching activities can only be evaluated in light of the ILOs that they should help to achieve. Therefore, in order to analyze TAs for the transfer of microscopy skills, the actual ILOs of microscopy-focused courses have to be clarified.

The analysis of 12 courses that have microscopy as their main focus shows that the transfer of theoretical knowledge regarding a respective microscopy technique is the most common aim, since it is stated as an ILO in 100 % of the course descriptions (Table 2.1).

Differences can be seen with regard to the degree that the student should be able to handle the microscopes independently. Only 42% of the courses define this as an ILO. In contrast to that, most courses aim to put students in a position where they can compare different methods and identify the most suited for a given sample (83%) and, extending this point, where students can formulate an imaging strategy for a given sample (58%). It can also be noted that most courses operate with standard samples instead of the student's own samples, which only 17% of courses refer to in their ILOs. However, discussing microscopy techniques suited for the student's samples is at least an ILO of 42% of the courses.

Table 2.1. Intended learning outcomes of 12 microscopy-centered courses taught at Danish Universities.

Intended learning outcome: students should be able to...	Percent
show theoretical understanding of respective microscopy method	100
compare different methods to identify most suited for a given sample	83
formulate imaging strategy for a given sample	58
use respective microscopy method independently	42
discuss microscopy techniques suited for their own samples	42
use microscopy data in further applications	33
optimally analyze their own samples	17
fulfil other method-specific ILOs	*42*

It can be concluded that while all courses intend to convey the theoretical background and to show students what techniques are available and when they could be used, only a subset of courses actually intends to teach practical skills that lead to independent usage of the respective microscope.

This has important implications for the employment of different TAs. Extended hands-on time, for example, might not be required for courses that do not aim to make students independent users of the microscope.

Undergraduate courses are not included in the table because they generally do not relate to microscopy skills in their ILOs. Asking lecturers and study program coordinators revealed a similar trend as described for graduate courses above, i.e. some courses do intend to teach practical skills, like "Methods in molecular biology" in Copenhagen University's Biotechnology Bachelor program, while most courses only focus on understanding microscopic images.

Virtual microscopy is not suited to teach skills related to practical microscopy

The analysis of ILOs of microscopy-focused courses showed that the main intention of many courses is not necessarily to educate the students to independently operate a specific microscope. Instead, the main learning goal is that students know which research questions can be solved with it and what requirements have to be fulfilled. In these cases, can virtual microscopy be an appropriate tool? This question is answered here by assessing the arguments of two University teachers that have opposing opinions on the value of virtual microscopy. It should be noted that the economic aspect that favors the use of virtual microscopy is disregarded here, since only its effectiveness for reaching microscopy course ILOs shall be assessed.

Dr. Ben Vainer, clinical professor in general pathology established virtual microscopy at Copenhagen University's Faculty of Health Sciences (Fjeldberg 2014). He sees the following advantages compared to conventional microscopy. For large classes, the laborious sample preparation, which was necessary before, can be omitted. Furthermore, learning is not hindered by problems associated with microscope operation and there are no sub-optimal samples. In addition, students can access images from home, allowing for more flexibility in using this TA. He received positive feedback from students, but has not evaluated if the student's performance in the respective exams improved (Vainer 2014).

Dr. Alexander Schulz, professor in cell biology at Copenhagen University's Department of Plant and Environmental Sciences, stresses the advantages of conventional microscopy. In his experience, it is a great teaching tool from a pedagogical viewpoint. Using the microscopes involves the students actively in the learning and provides a change from the student's focus on a lecture or computer screen (Schulz 2014). Moreover, students get valuable experience with variable sample quality that is not possible by only seeing optimal slides. It also provides an opportunity for direct interaction between supervisors and students that can be beneficial for the learning experience. Furthermore, he made the experience that actually using research tools like microscopes kindles the interest of students in doing research, encouraging them in their research career path.

In Dr. Vainer's teaching setting, the effort associated with the use of microscopes is distracting the students from learning about medical conditions (Vainer 2014). In other words, the advantages of virtual microscopy are most relevant in courses where microscopy as a technique is not part of the content. This is also true for the cell biology courses taught by Prof. Schulz. Nevertheless, he uses conventional microscopy, because it is a more valuable TA compared to virtual microscopy in his experience. In this way, both teachers actually agree that virtual microscopy is a tool to teach microscopy-related content without the need to discuss the technique itself.

What does this mean for the present question whether virtual microscopy is a suitable tool for courses with the aim to teach students theoretical background of a specific microscopy technique and how it can be applied? Two arguments against the use of virtual microscopy in this context are brought up by Prof. Schulz. One is that without seeing samples of varying qualities, students cannot judge what kind of images can be produced with a certain microscope. As Prof. Schulz says: “Students have to get an eye for the quality of a sample. Because of the fact that the course organizer is preselecting the best slides, the students lack to get trained in this judgment” (Schulz 2014). Even though the ILOs of the courses in question do not involve independent operation of microscopes, they do include the ability to judge the potential of a specific microscopy technique. This ILO cannot be realized by using virtual microscopy.

The other argument is that without handling microscopes, students do not learn how much time and effort is required to produce a good image with a given microscope (Schulz 2014). This limits their ability to judge if this microscope is suited to solve a specific research question. This means that virtual microscopy also limits the possibility of achieving the ILO of being able to develop imaging strategies and choosing the most appropriate microscope technique for a given sample.

Hands-on time has to be balanced with extensive theoretical explanations for successful teaching of microscopy handling skills

In order to assess the value of different TAs for a microscopy-focused course, student evaluations of one course that is taught in every year were analyzed. The course ILO specifically include that students should learn to operate the microscopes independently. Therefore, a large part of the course is dedicated to hands-on time during which students, in groups of two, use different microscopes. They analyze samples that they prepare themselves according to instructions in the course manual. The hands-on part is complemented by a theoretical introduction and a journal club. The students have to prepare a report that includes their result for each course day. In the three years from which evaluations were available, the level of expertise of the students was comparable, as indicated by the quality of the reports and the impression of the teachers. The only change that was made to the course structure was that in the third year (2014), the time used for theoretical explanations was increased to about 20% of total course time, compared to about 10% in the two previous years. In addition, the supervision of hands-on exercises was extended.

From the student's course evaluations, four questions were relevant in the present context:

1. "Did the course in general fulfil your expectations?"
2. "Was the balance between theory and hands-on at the microscopes good?"
3. "Did the course manual meet your needs?"
4. "Did the journal club sessions work out?"

These questions were answered by the students on a scale of 1 to 5 with 1 corresponding to "no" and 5 corresponding to "yes". The proportion of students that answered a question with "yes" (5 points) in each year is plotted in Fig. 2.1. There is no qualitative difference if instead of only the top mark all five answering options are taken into account via a weighted point system. A table with the complete data is included in Appendix A.

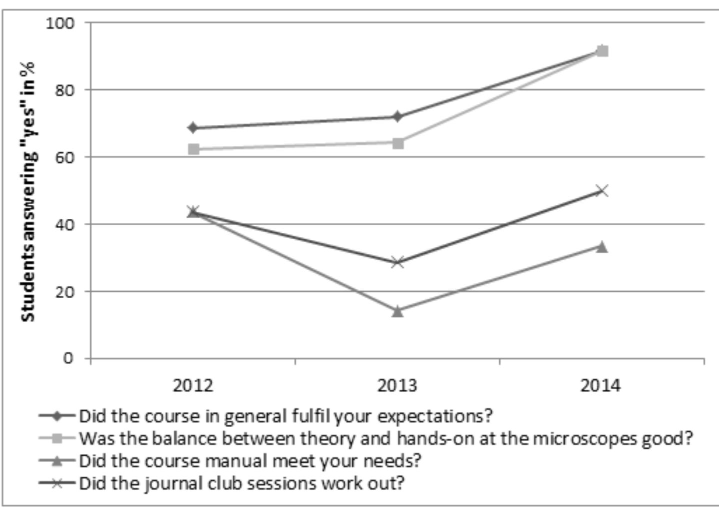

Fig. 2.1. Student evaluation of the course "Advanced Methods in Microscopy"

The overall satisfaction of the students with the course is considerably higher in 2014 compared to 2012 and 2013 (Fig. 2.1).

The coincidence of higher satisfaction with the course in general and the balance between theoretical and practical parts, while other values are rated as in previous years indicates a causal connection. This indication is supported by the fact that the time distribution between theory and practice was changed for the 2014 course. This seemed to have had a positive effect on the student's rating of the course in general.

Further evidence for the importance of the theoretical explanations is provided by several students of the 2012 and 2013 courses that made comments on the evaluation forms stating that theoretical explanations should be extended. For example, one student writes; "explanation for hands-on should be more detailed". The comments also indicate the student's general preference for supervised training instead of independent hands-on. One student writes in the evaluation of the 2012 course: "I would like to see 'the expert at work' in between theory and our own hands-on time". This could also be a factor in the good evaluation of the 2014 course, in which more supervision was provided.

The relatively low ratings of the journal club in all years indicate that this TA might not be well suited for this kind of course. Several students commented that the papers discussed in the journal club were not relevant for learning the microscopy methods that are part of the hands-on exercises.

Discussion

The results from this study provide insight into how students learn to operate microscopes and advance the debate on the effectiveness of different teaching activities.

The ILOs of courses that have a specific microscopy technique as main subject were shown not always to include the student's independent handling of microscopes. Instead, understanding of the theoretical background and the ability to choose the right technique for a certain sample are the aims that are universal in microscopy-focused courses.

Only online course descriptions were taken into account when the ILOs were analyzed. It could be the case that different or additional ILOs are presented within the course. However, only courses taught at Danish Universities were considered and Danish University teachers generally receive pedagogical training that encourages the use of precise ILOs in the course description.

Virtual microscopy has found entrance in numerous teaching situations, but mainly in Bachelor level medical training that does not aim to transfer practical microscopy skills **??**. In many cases the switch from conventional to virtual microscopes was triggered by economic considerations (Kumar et al. 2006, Krippendorf & Lough 2005). Virtual microscopy does not require laborious preparations before each teaching session and makes going through slides faster (Fjeldberg 2014, Kumar et al. 2006). Thereby, as Kumar et al. found, it helps to "minimize the adverse impact of curriculum reform on the teaching of morphology" (Kumar et al. 2006). Nevertheless, while students appreciate the accessibility of virtual microscopes, they would actually prefer at least a combination with conventional microscopy (**?**Amyanwu et al. 2012). In general, student learning is not enhanced by the use of virtual microscopy compared to traditional microscopy instructions (Krippendorf & Lough 2005, Helle et al. 2011). It can be concluded that, that virtual microscopy is a TA that can help to make teaching more efficient.

For the courses discussed here, however, the opinions of two experienced University teachers indicate that virtual microscopy would be only of limited usefulness. Especially the important ILO that students should be able to compare different methods to identify the most suited for a given sample cannot be fulfilled. This is supported by observations that students lack the concept and appreciation of the sources of tissues and images when only using virtual microscopes (Harris et al. 2001).

However, also in the present context, virtual microscopy might facilitate the realization of some ILOs when complementing hands-on focused TAs. For example, the student's understanding of theoretical background of certain techniques might benefit from virtual microscope exercises that they can complete independently at home.

With regard to the value of other TAs, information is provided through the student evaluations of a microscopy-focused course in consecutive years as presented here. The analysis is based on course evaluation sheets, which provide less information than a tailored questionnaire would. However, the high answering rate, here between 74% and 80% ensures credibility. Such answering rates would be difficult to achieve with separate questionnaires. Moreover, evaluation sheets were completed right after the courses were held, when the students still remember all details of the course. In addition, evaluations were accessible for consecutive years, which was critical for this study.

The results show that even in hands-on focused courses, students put strong emphasis on a thorough theoretical background and getting to know the different techniques. Extended theoretical instructions led to significantly better evaluation of the course in general, demonstrating its importance for achieving the course ILOs. Other TAs that help the students in their learning are expert demonstrations and extensive supervision when handling the microscopes themselves. Journal clubs, however, do not seem to be a suitable TA, generally receiving low scores in the course evaluations. The missing relevance, which is highlighted in student comments, might be partly connected to the journal club implementation, which lets students choose a paper themselves. An option could be to connect paper discussions with case-based learning. With its direct connection of research questions and hands-on exercises it can provide increased exposure to theoretical background and additional guidance for the hands-on part.

A Appendix

Data from student evaluation forms for the course “Advanced Methods in Microscopy”. Values are given in % of the number of students that completed the evaluation form.

	No				Yes
Did the course in general fulfil your expectations?					
2012	-	-	6	25	69
2013	-	-	7	21	72
2014	-	-	-	8	92
Was the balance between theory and hands-on at the microscopes good?					
2012	-	-	19	19	62
2013	-	-	14	21	65
2014	-	-	-	8	92
Did the course manual meet your needs?					
2012	-	-	19	37	44
2013	-	-	36	50	14
2014	-	-	25	31	44
Did the journal club sessions work out?					
2012	-	6	6	44	44
2013	7	-	21	43	29
2014	-	-	17	33	50

3

Introducing Nanoscience to Students at University – Five years of experience with 'Nano1' – a Research-Based Introduction to Nanoscience

Thomas Just Sørensen

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Introduction – Nanoscience & Research-Based Teaching

Introducing new students to their chosen field of study is difficult, as the students have to *learn* about their chosen field of study and *integrate* into the new university setting (Biggs & Tang 2011*b*, Dolin 2013, Johannsen et al. 2013). In multidisciplinary fields of study the challenge is considerable, as the students have to learn about and familiarize themselves with several disciplines (Dolin 2013, Rienecker, Müllen, Dolin, Musaeus & Mørcke 2013). In some cases, the students do not have the knowledge needed to perceive the scientific substance of their chosen field of study. The students that enroll on the nanoscience education at the University of Copenhagen have to face the challenge of integration, while learning the course matter of the undergraduate degree programme in nanoscience, which is primarily taught as physics, chemistry, and biology. To help the students take charge of their progress towards becoming a nanoscientist, an introduction course named 'Nano1' is included in the nanoscience degree programme. The Nano1 course was redesigned in 2010 as a research-based course predominantly consisting of a laboratory project. Here, the course rationale is detailed, and the course analyzed using a constructivist framework.

Research-based teaching at the undergraduate level has been successfully implemented in chemistry courses (Dintzner et al. 2011, Kharas 1997, McKenzie et al. 2012, Newton et al. 2006, Tomasik et al. 2013, 2014), with a genuine research outcome reported in several cases (Kharas 1997, Newton et al. 2006). While all reported cases are examples of active learning (Prince

& Felder 2006, Weaver et al. 2008), various forms of inductive learning are applied, typically starting with a guided-inquiry approach that to varying degrees move towards open ended discovery learning as the course progresses (Prince & Felder 2006). One report highlights the necessity of this progression, as the students need to learn how to perform research, before being asked to undertake an independent research project (Newton et al. 2006). All reports highlight the exceedingly positive student response to active learning and research-based teaching (Biggs & Tang 2011*b*, Dolin 2013, Prince & Felder 2006, Tomasik et al. 2013, Weaver et al. 2008). As student motivation is an important aim of an introduction course, an active learning approach in the form of research-based teaching was an obvious choice when redesigning the Nano1 course.

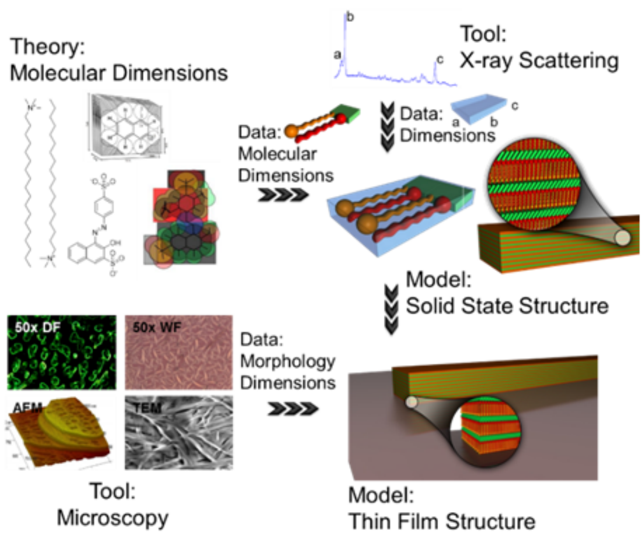

Fig. 3.1. The part of the Nano1 research project working with the structure of matter and molecular dimensions.

Nanoscience is hard to define. Nanomaterials are defined as to materials with one or more dimensions between 1 nm and 1000 nm. At the University of Copenhagen, nanoscience is defined as research using tools that measure on the nanoscale, typically research also involving nanomaterials. In addition, nanoscience at the University of Copenhagen is strongly rooted in the parent disciplines of chemistry, physics, biology, and medicine with regard to both education and research. In order to focus on nanoscience and nurture the student's identity as nanoscientist, the Nano1 course focuses on the tools and dimension of nanoscience rather than discipline related content.

The research project Nano1 revolves around is based on the work of Faul (Gaun et al. 2002), which described the fabrication and investigation of a series structured nanomaterials. These materials can be processed into films, allowing for three kinds of samples to be investigated using the tools of nanoscience: solid samples, samples in solution, and film samples. Furthermore, the constituents of the materials have dimensions and properties that are highly relevant in nanoscience, which allows for introduction of several important concepts. Figure 3.1 shows the relationship between the different aspects of the Nano1 research project concerned with structure. This part of the course, representing roughly half of the scientific content, involves five important nanoscience tools. In total, the students use no fewer than eight different nanoscience tools in the five weeks in the laboratory.

Theoretical Framework – Constructivism

Constructivism in language and education is based on the works of Vygotsky and Piaget, both working in the beginning of the 20th century (Dolin 2013, Glassersfeld 2005, Pritchard & Woollard 2010). Starting as field of epistemological philosophy the constructivist idea has moved into to field of teaching and has found support in cognitive biology (**?**Pritchard & Woollard 2010). The fundamental concept in constructivism is that a person perceives a subject based on previous knowledge, that is, a new concept cannot be transmitted from a teacher to a learner (*positivism*), but the learner has to build an understanding of the new concept based on previous experiences and knowledge (*constructivism*). Schools has arisen within constructivism as to whether the process of learning is exclusively a social phenomenon (*social constructivism*) or whether the process takes place exclusively within an individual (*radical constructivism*) (Glassersfeld 2005, Pritchard & Woollard 2010), but for a teacher the truth is most likely found on the middle ground. The different settings for learning automatically engage students in a manner that can be associated with either form of constructivism: the classroom is a social setting, group-work is a social setting, while reading a textbook or completing set problems takes place within the individual.

In the context of a university introduction course, three key concepts from constructivism can be considered: *i)* Bruner's spiral curriculum, *ii)* Vygotsky's Zone of Proximal Development, and *iii)* the general concept of 'scaffolding' in instruction (Pritchard & Woollard 2010). In summary: Bruner's Spiral curriculum suggests that important concepts should be introduced and re-introduced frequently throughout an education, Vygotsky's Zone of Proximal Development is the scope of new concepts a student is capable of learning if instructed, and 'scaffolding' is the general means employed by the instructor to enable the students to pass through/encompass the zone of proximal development:

> "*...the teacher need to construct a hypothetical model of the particular conceptual worlds of the students they are facing. One can hope to induce changes in their [the students] way of thinking only if one has some inkling as to the domains of experience, the concepts, and conceptual relations the students possess at the moment.*" (Ernst von Glassersfeld (2005))

Vygotsky's Zone of Proximal Development in particular will be detailed below and used as a model throughout the text, while Bruner's spiral curriculum and scaffolding is simply adopted as valid concepts in e.g. curriculum planning and the design of teaching activities.

Rationale – Course Design

When redesigning the Nano1 course in 2010 the two major concerns were: How to integrate the students into the nanoscience community, a community constituted primarily by university students, while all instructors and researchers are chemists, physicists, and biologists. And how to teach a complex and undefined multidisciplinary field of study to a diverse group of students.

A theoretical solution did not present itself, and it was decided to plan a research-based laboratory course involving the largest possible number of nanoscience related tools, concepts, and techniques. The goals of the Nano1 course was defined, and are:

- to give the students a common frame of reference to build their further studies on
- to put rudimentary practical and leaning skills in place for the students to use in their further studies

- to introduce the students to the multidisciplinary field of research that is nanoscience

Table 3.1. Concepts the students have to use in the Nano1 course. The evaluation is indicated behind each concept, the exam paper (ex) is summative while the students receive formative feedback on their laboratory group report (lr) and individual lab book (lb). The oral presentations are concluded by one general feedback session.

Declarative knowledge	Functioning knowledge	Both
Molecular dimensions (**lr**/**ex**)	Laboratory safety (**lb**)	Chemical synthesis (**lb**/**lr**)
bond lengths and angles (**lr**/**ex**)	Documentation (**lb**)	Elemental analysis (**lr**)
atomic radii (**lr**/**ex**)	Solid and solution handling	Mass spectrometry (**lr**)
Functional groups (**lr**/**ex**)	Laboratory glassware	Optical spectroscopy (**lr**/**ex**)
Intermolecular forces(**lr**/**ex**)	Data analysis (**lb**/**lr**)	Optical/electron microscopy (**lr**/**ex**)
Electrostatic forces(**lr**/**ex**)	Word processors (**lr**/**ex**)	Atomic force microscopy (**lr**/**ex**)
Hydrophobic interactions (**lr**/**ex**)	Spreadsheets (**lr**/**ex**)	X-ray scattering (**lr**/**ex**)
Qualitative and quantitative analysis (**lr**/**ex**)	Scientific writing (**lr**/**ex**)	Primary literature (**lr**/**ex**)
	Scientific oral presentations	Information gathering (**lr**/**ex**)

To meet those goals a course was designed were the students attend lectures and tutorials aimed exclusively at ensuring that the students have the skills needed to perform the research-based laboratory part of the course. The lectures cover concepts the students are to use actively in their research, and all concepts are accessed with at least one round of formative feedback. The concepts that are intended learning outcomes of Nano1, divided into declarative and functioning knowledge where possible (Biggs & Tang 2011*b*), are listed in table 3.1. The form of the feedback is indicated in table 3.1.

Student Integration

While off-topic here, the course design was strongly focused on student integration. The Nano1 course is the first nanoscience course the students face, and is one of two courses the student take in the first quarter of the first year of university. The students arrive from high school and have to start integration on several levels (Johannsen et al. 2013):

- Practically and socially outside university
- Socially within the year group

- Professionally in a new discipline
- As a university student

The Nano1 course aims at helping the student in the process of adapting to university. The course is designed to force the students to interact within the year group, to force the students to employ several beneficial techniques for university learning, and to give the students a shared experience within the year group and within the field of study.

Learning

Teaching in a constructivist view has to start by adopting the viewpoint of the students. When receiving new students at university the constructivist approach dictates that the status of the student is evaluated in order to map what the student knows and can perceivably learn. The students come with a background within a given discipline, seeded in primary school and cultured in high school. Learning requires that the lessons are structured according to the areas of a discipline where the students have a proficient understanding (Pritchard & Woollard 2010). From this starting point, a lesson may enable the student to learn, and expand the part of the discipline where the student demonstrate a proficient knowledge. This process can be visualized by using Vygotsky's Zone of Proximal Development, see figure 3.2 (Dolin 2013, Pritchard & Woollard 2010). For the most efficient

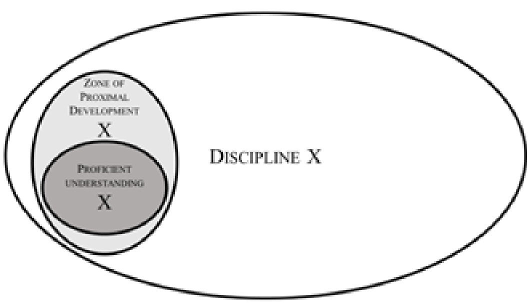

Fig. 3.2. Vygotsky's Zone of Proximal Development, or in context of university learning, a visual representation of what the student know, what the student are able to learn in a given timeframe, and what the student should learn in a given discipline (chemistry, physics, biology, medicine or more specific organic chemistry, inorganic chemistry, theoretical chemistry etc.).

learning to take place the students should have similar backgrounds, in order for their background knowledge and zones of proximal development to overlap. If this is the. case, then each lesson can challenge the students at the highest possible level, maximize learning, and cover the discipline at the most rapid pace. This can also be understood as a steep learning curve, which employed will alienate all the students that have a background less suited for studying the specific discipline (Dolin 2013). The best possible candidates are produced in this manner, but this form of teaching is ill suited to a mass university.

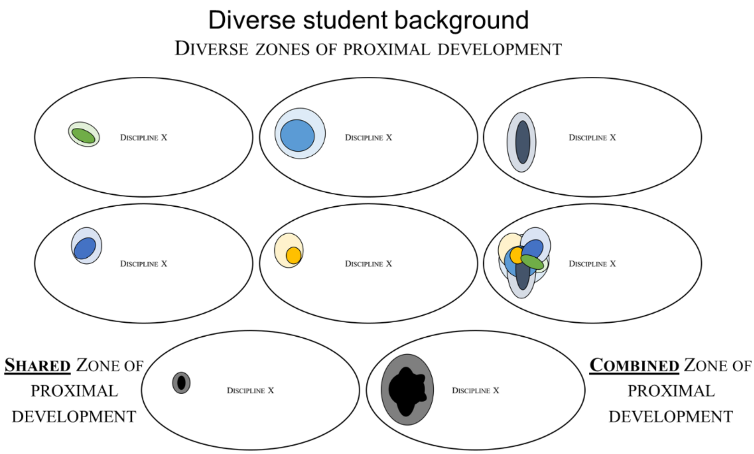

Fig. 3.3. Vygotsky's Zone of Proximal Development for a typical student group enrolled at the nanoscience education at the University of Copenhagen, where the students are strong in multiple but different disciplines. Here, three groups are weak in discipline X and two groups are strong. Constructivist lessons can build on either the shared knowledge or the combined knowledge of the student group.

Vygotsky's Zone of Proximal Development can be used as a strong visible representation of student knowledge, student learning potential, and the content matter the student has to master at a certain level at university. Each student or group of students will come with different knowledge and expand that knowledge differently. By using a visual representation of the differences in knowledge and progress, a qualitative evaluation/analysis of student learning is feasible. Moreover, conceptually, course planning can take the differences in student background into account by mapping out the student knowledge using Vygotsky's Zone of Proximal Development as a graphical representation of student knowledge.

In the nanoscience education, the challenge of student background is multiplied. A much more varied student group is accepted compared to the traditional disciplines. Figure 3.3 shows a graphical representation of the diverse student group. Ideally, the first courses the students are met with should homogenize the student group to the extent that they have equal chances to learn in the following courses. This can be done using a classic lecture format provided scaffolding based on the *shared zone* of proximal development, or in an active setting, where the students are engaged at the extent of their *combined* capabilities, the difference in area of a discipline covered is shown in figure 3.3. While time consuming for instructors and teaching assistants, the learning outcome of the second approach is highly favorable.

In the Nano1 course, two types of teaching/learning activities are in place: the facilitating series of lectures and the laboratory project. Both are aimed at the combined zone of proximal development shown in figure 3.3, where the lectures relies on peer instruction and small group discussions during the laboratory project to compensate for the differences in student background.

Teaching a Multidisciplinary Field of Study

In nanoscience, the problem of a diverse student background mirrors the problem of teaching a multidisciplinary field of study. While nanoscience is defined as pertaining to matter and materials defined by having at least one dimension measured on the nanometer scale, the field of study is located at the point where multiple traditional disciplines overlap or interact, see figure 3.4. Essentially, basic nanoscience does not exists. Rather, basic nanoscience is the combination of advanced physics, chemistry, biology, and medicine. In a course introducing first year students to nanoscience, their background does not include the concepts needed to comprehend the nature of nanoscience, see figure 3.4. Furthermore, the instructors the students meet are not nanoscientist, but are heavily rooted in chemistry, physics and biology, and are as such not familiar with the scaffolding needed to aid the first year students in becoming nanoscientist from a nanoscientist's perspective. The instructors can only help the nanoscience students from a biologist's perspective, chemist's perspective *etc*. In introducing nanoscience to the students, different means have to be applied. If the first year students cannot *learn* the multidisciplinary aspects of nanoscience until later in the education, they have to be familiarized with nanoscience in a different manner. Nano1 uses the tools of nanoscience as the means to introducing the students to nanoscience by having them *do* nanoscience.

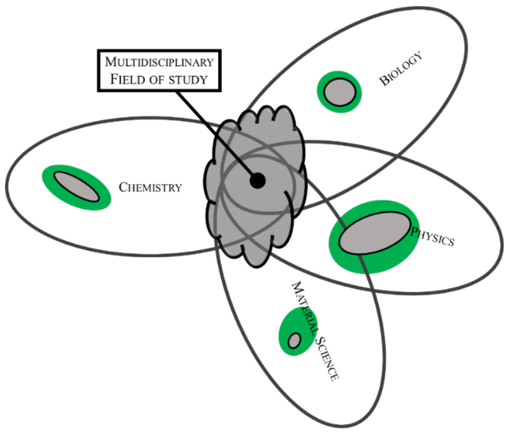

Fig. 3.4. The problem of teaching a multidisciplinary field of study illustrated using Vygotsky's Zone of Proximal Development in various disciplines.

Nano1 – Introduction to Nanoscience

The Nano1 course have run successfully for five years, with positive student feedback, successful research outcomes (Marco Santella et al 2015), and a clear progression in student learning outcomes as the course has evolved. A detailed account of the course will be given elsewhere. (Thomas Just Sørensen. A Research-Based Laboratory Course for First Year Undergraduate Teaching, Manuscript in preperation)

While building on the strengths of the individual student, the research-based Nano1 course also caters to peer-instruction based on the individual strength, and this approach to teaching allows for covering a wide scope of very advanced material that will be new and challenging to all students. Furthermore, by adopting a research-based approach, multiple techniques and concepts relevant for the chosen discipline can be introduced actively to the student, touching down on important formulas or concepts that the students will have to work with for an extended period of time. The research-based course allows the student to work hands-on with nanoscience and actively do research, neither of which they would do prior to their third year under different circumstances.

Returning to the desired learning outcomes of Nano1, as listed in table 3.1, they fall into two categories: discipline-related concepts and secondary skills. The latter of the two are easily taught as all the students have a working experience with computers and the internet, and as such, a common background easily addressed by lectures and tutorials. The former is more difficult, due to the issue outlined in figure 3.3. In Nano1, this is tackled as the research project, through peer instruction and numerous contact hours, makes it possible to teach based on the common zone of proximal development. The issue of the distance between the student's discipline-dependent zones of proximal development and the multidisciplinary nature of nanoscience is dealt with by letting the student work towards a simple functional proficiency in several nanoscience related techniques. In the lab, the students perform experiments, which they are fully capable of comprehending. They then independently perform data analysis on a level they understand, while subsequent advanced data analysis is performed by following a recipe. The results are designed to lie within the limits of the student's zone of proximal development, enabling the students to explain the results. Using the SOLO taxonomy the several levels of understanding is mapped as zones of proximal development in figure 3.5 (Biggs & Tang 2011*b*). While the students will not be able to learn or reflect on nanoscience during the Nano1 course, they will be able to *do*, *explain* and *apply* various aspects of nanoscience. The greatest challenge in planning and executing the Nano1 course is to match the teaching to the student group's version of figure 3.5.

Evolution – Lectures and Tutorials

he first iterations of the course ran with a pure positivistic approach by choice, which was partially successful in that the students in general came with a solid background in chemistry and physics. The second iteration, following on from the success of the first, was a complete failure of the transmissive lecture format; possibly do to a vastly different student group. The

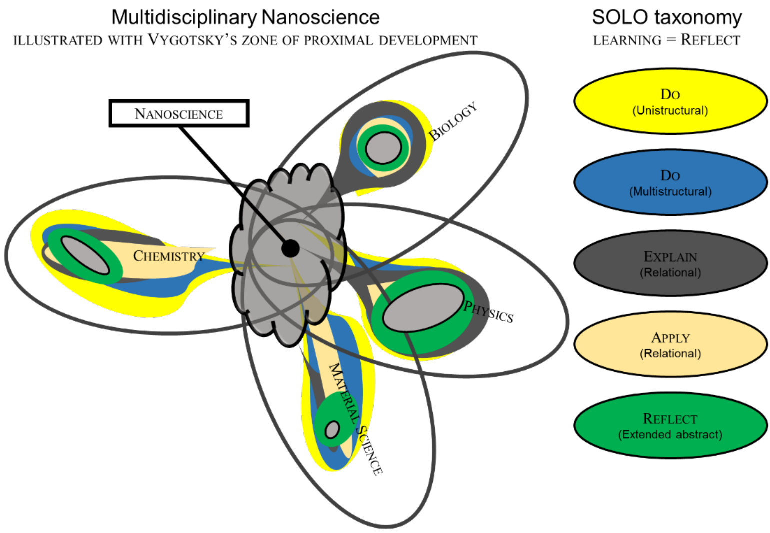

Fig. 3.5. A typical map of the discipline dependent zones of proximal development at various levels of understandings of a first year nanoscience student at University of Copenhagen.

failure suggested a more student-centered approach to the lecture part of the course. The research part of the course is intrinsically student-centered.

To make the lecture course more student-centered, the first task is to investigate where the students are when they arrive at university. They all come from a high-school background, where they have focused on various disciplines, but they will all have had mathematics and a minimum of two of the following: physics, biotechnology, geoscience, and chemistry. They do not have any knowledge of nanoscience and they do not have overlapping competencies within any area of science besides mathematics. The five iterations of Nano1 has shown that the students have poor secondary skills, as they have not been trained to use word processors nor spreadsheets professionally, and the student have not had experience in independently researching a subject using the internet, libraries, and other available sources of knowledge.

The initial assumption was that a transmissive approach to lecturing, where the content of each lectures gives a condensed account of the theory behind each applied technique, would fulfill the goals of Nano1. The idea was that the student would thus be taught the skills listed in table 3.1, and able to actively apply the information in the relevant part of the research project. This assumption was proven to be flawed and a radically different approach had to be adopted. Where the initial idea was to *expose* the students to the theory behind listed skills at a very high level during the lectures, the focus was gradually shifted towards that the student *learn* the basic concepts of each technique, ensuring that all students have a working knowledge of the techniques they are to actively use in the research project.

In the latest, fifth, iteration of the course the appropriate level for lectures has been found, where the diverse student group all are able to explain the foundation of the techniques they have actively used. This is evident from the exam papers.

Evolution – Laboratory Research Project

The research project has worked perfectly in the execution of the experiments in all five iterations of the course. The first two iterations suffered from poor documentations, but a clear focus on this aspect throughout the course has made the student lab books acceptable with respect to reproducibility. In most other aspects, the quality is still poor, which serves to highlight the difficulty in keeping a proper laboratory account. An experience the students take with them into the remainder of the degree programme.

The biggest challenge in this course is to achieve a high quality in the written laboratory report (based on the laboratory experiments). The students repeatedly fail to produce high quality work despite the 100+ student hours they have to write the report. The reason for the lack of quality has been identified. I reason that it is partly due the fact that the students have to do the data analysis in the writing process. And partly due to the general lack the secondary skills i.e. the ability to operate spreadsheets and word processors. By ensuring that data analysis is performed prior to the time allocated to writing the report, time to sort out the secondary skills should be available. It is clear from the exam papers that the secondary skills are in place after having written the laboratory report.

It has previously been noted that the students like to be able to perform a model experiment/model analysis prior to performing the research based task (Newton et al. 2006). Therefore, in the sixth edition of Nano1, a written formal data analysis guide and a model data set will accompany each experiment, with the result shown in the form of a graph or table. Furthermore, the data analysis will be integrated within the ‘experiment time’ in the course schedule, rather than appearing as several congregated blocks of ‘data analysis time’. In this manner the data analysis should be in place when the writing process starts, and the use of spreadsheets should be reinstated, thus allowing the writing process to be focused on scientific writing and using word processors. This is a clear step towards a guided-inquiry approach away from discovery learning where this course started (Prince & Felder 2006, Weaver et al. 2008). However, attention to the student learning outcomes clearly indicates that in teaching first year students this is a better format. The course could be repeated at a later stage in the education, where a more open discovery learning approach can be used.

Discussion

As student integration is essential, we start by considering the effects of the Nano1 course on student integration. A research-based course gives unique handles to nurture student integration. Working in groups, directly experiencing nanoscience tools, working with postgraduate nanoscience students (as teaching assistants), and working on an individual and novel research project are all factors that work well towards student integration within the year group and the discipline. A key aim in the Nano1 course is to instill the students with an identity as nanoscientists. As each year group is directly involved in a nanoscience research project, using the tools of nanoscience on an unexplored system, they are given a common identity within the year group. As each year group has been through similar although not identical, but progressive research project based exclusively on the work of previous year groups, the experience can be used to give the students across year groups a shared identity. Furthermore, the successful research projects result in publications with student authors, making the students published researchers, which effectively integrate the students in both of the two communities present at universities: the research community and the educational community (Ulriksen 2009). Nano1 allows the students to be part of the research community from the first year, rather than in the third year where they perform research as part of their bachelor projects.

Concerning student learning, the Nano1 course have changed in focus and means over the five iterations. The analysis presented here based on constructivism in general and Vygotsky’s Zone of Proximal Development in particular, highlight the difficulty in teaching nanoscience to first year students. However, the analysis also shows how nanoscience can be taught to a diverse group of first year students by using a research-based active learning approach. The analysis suggests that enrolling a more homogenous student group would enable more ambitious levels of student learning to be achieved.

The experience from creating, implementing, and developing Nano1 show that research-based teaching is feasible, and that the research part of such a course is readily planned and implemented. The support structure in the form of lectures and tutorials is essential for student learning, but are much more difficult to plan. Only by using a constructivist approach can the optimal format for student learning be realized. Nano1 was developed iteratively, which worked well because the vast benefits of research-based teaching compensated for the less than perfect lectures. Based on the experiences with Nano1 an iterative approach to develop research-based courses is suggested, unless the student group is very well known. As presented above, the student knowledge and their potential for learning is very complex (figure 3.5), consequently, detailed course development may be in vain if even small changes in student population occur.

Conclusion

Introducing nanoscience to first year university students remains a challenge. By using Vygotsky's Zone of Proximal Development as a visual representation of student knowledge and potential for learning, the course 'Nano1 - Introduction to Nanoscience' was analyzed. The analysis shows that, with appropriate scaffolding, students can be introduced efficiently by using a research-based form of active learning. Furthermore, the analysis using zones of proximal development visualizes the advantage of a student centered active learning approach over a traditional lecture format. The same method of visualization allow for a clarification of the issues inherent in teaching and learning multidisciplinary fields of study, and further allows for a mode of action to be selected in introducing multidisciplinary fields of study: By selecting a few points within the multidisciplinary core, in which the students are able to either *do* research or *explain* research-based results, a multidisciplinary field of study such as nanoscience can be introduced to the students in an actively learning setting early in a university degree programme.

Acknowledgements

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4

Planning and redesigning the laboratory component of a compulsory bachelor of pharmacy course

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Background

The study board, the teaching committee and the head of department launched the Farma2020 process in January 2014. The process consists in a complete redesign of the bachelor education in pharmacy. In the new overall course structure, all courses are worth 7.5 ECTS where 1 ECTS point equals a student workload of 30 hours. In this context, course development teams were formed in order to adapt the former courses to the new program. As a member of the course development team for the bachelor course "Instrumental Analytical Chemistry", I have been tasked with helping with the redesign of this compulsory course.

The Instrumental Analytical Chemistry course is a compulsory 8 ECTS course, which is comprised of lectures accompanied by a strong laboratory component. As seen in Figure 4.1, the course normally enjoys good ratings among the students. The most mixed feelings among the students relate to the course lectures, which was either the cause or the consequence of a very low student attendance (typically less than 50%). The results from the course evaluations have been more or less similar since 2006, with slight increases in satisfaction regarding the theory section of the laboratory manual, the description of the exercises in the laboratory manual, the usefulness of the exercise questions with helping to learn the theory, the usefulness of the student-teacher discussions upon returning of corrected reports and the use of English in the laboratory manual.

Even though the reviews from the students were generally positive, some improvements to the course are still necessary as in 2014, a signif-

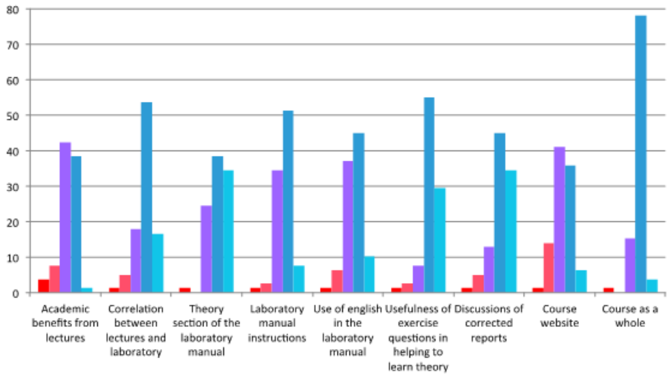

Fig. 4.1. Overview of student evaluations for Instrumental Analytical Chemistry (2014)

icant fraction of students failed the final examination and answers to the examination questions reflected that a good proportion of students could surprisingly still not perform rudimentary calculations related to basic laboratory tasks.

The "new" course – Pharmaceutical Analytical Chemistry

Despite the general satisfaction with the original Instrumental Analytical Chemistry course, especially its laboratory component, the whole course needs to be re-designed as part as the general re-design of the bachelor education. The re-design is characterized by a better communication among various course teams so as to avoid repetitions and/or glaring omissions in the curriculum material. Some of the subjects currently covered by the Instrumental Analytical Chemistry course are already or will be covered in different courses. A complete redesign of the laboratory component of the course is therefore required. In the new version of the laboratory course less subjects will be covered but they will be covered with more depth and the students will have more time to complete and reflect on each experiment.

The new course is tentatively re-baptized "Pharmaceutical Analytical Chemistry" (Farmaceutisk Analytisk Kemi) to better reflect its content and will be taught in the 4th semester. By then, the students are already quite mature in their education and have gained considerable laboratory experi-

Table 4.1. Comparison of the layout of the "old" Instrumental Analytical Chemistry with the "new" Pharmaceutical Analytical Chemistry

	Instrumentel Analytisk Kemi ("old course")	**Farmaceutisk Analytisk Kemi ("new course")**
Points	8 ECTS	7,5 ECTS
Structure	Lectures (3 ECTS) + laboratory (5 ECTS)	Lectures + laboratory (7,5 ECTS)
Experiments	12 "cookbook" experiments + 1 project based on the pharmacopeia	4 experiments requiring the students to participate in experiment design
Reports	Students fill out a questionnaire in lieu of writing a report	Students should write a laboratory report
Grading	Laboratory course: Pass/Fail (reports) Lectures: Graded (final examination)	Laboratory course: Graded (reports) Lectures: Graded (final examination)

ence. They have been taught to work with the diverse pharmacopeia methods (a compendium of analytical methods for pharmaceutical products) in two different courses during their first semester in the pharmacy education (Lægemiddeludvikling fra molekyle til menneske – oversigtkursus and Kemiske principper for de farmaceutiske videnskaber) and learned general laboratory practices in several other pharmacy courses (Kvantitativ Analytisk Kemi, Farmaceutisk fysisk kemi 1 & 2).

Table 4.2. Pharmaceutical Analytical Chemistry laboratory course overview

Farmaceutisk Analytisk Kemi – Laboratory component	
Exp 1: HPLC	6 x 4hr sessions
Exp 2: LC-MS	3 x 4hr sessions
Exp 3: GC-MS	2 x 4hr sessions
Exp 4: AAS	2 x 4hr sessions

The new course is scaled down from 12 experiments plus one final project to just four experiments as listed in Table 4.2. We focus here on the redesign of experiment 1 (HPLC). The original experiment, outlined in Table 4.3, is fairly standard for an Instrumental Analytical Chemistry course. Experiments are performed in teams of 2 to 3 students and only one form-based "laboratory report" is submitted for the team.

In the new course, the HPLC experiment will be now spread out over six 4-hour sessions to allow the students more time for preparation, reflec-

Table 4.3. Outline of the original HPLC experiment

Activity	Task
Experiment (One 4h-session)	Perform a "cookbook" type experiment with the aid of the laboratory manual
Laboratory report	Fill-in a report form and answer 11 post-lab questions. Only 3 questions can only be answered by looking at the students' experimental data. The students look for the answers to all other 8 questions in the lab manual and/or course textbook. The report is graded on a Pass/Fail scheme.

tion and experimentation. There is no laboratory manual, but instead, the students use the literature (the pharmacopeia) as a starting point to design their own experiment. The 6 sessions of the HPLC experiment are detailed below.

Prior to the first session: Reading and "pre-lab" questions

In order to prepare the students for the experiments, the students are required to perform some readings as well as to answer pre-lab questions. The answers to the pre-lab questions are not graded but will be discussed with an instructor prior to the beginning of the experiment. The pre-lab questions ensure the students have done the required readings, but also that important points related to the operation of the instruments are discussed prior to the beginning of the manipulations to avoid errors and/or damage to the instruments.

Session 1-3: Pharmacopeia methods

In the new course, we chose to part ways with the "cookbook" type laboratory manual. It has been observed that when the students follow detailed instructions, they tend to focus more on completing the activity then on trying to make quality observations or develop connections between their own experimental results and the related theory. Students from the pre-university programme in Malaysia who enrolled in the undergraduate pharmacy education were observed to have lost their skills of writing and analytical thinking as they depended much on the laboratory manual (Abidin et al. 2013). Also, in the absence of a "pre-lab" questionnaire, only a handful of students will take the time to read and understand the laboratory manual prior to performing the experiment (Arnold et al. 2014, Parry et al. 2012).

There are two types of knowledge we desire the students to gain from the laboratory experiments: Substantive knowledge, which is “the understanding of scientific facts, concepts, laws and theories” (Arnold et al. 2014) and procedural, or epistemic, knowledge and understanding, which includes “knowledge about methods, when and how to use them, and their limitations” (Arnold et al. 2014). Problem-Based learning and Enquiry-Based learning are often recommended for teaching and learning in the laboratory (Abidin et al. 2013, Arnold et al. 2014, Moskovitz & Kellogg 2011). These teaching methods start with a question, or a problem, which needs to be solved with minimal guidance. Here, designing the experiments is key to the students’ learning process. If the students are able to design a valid and reliable experiment to solve the problem or answer the question, they will be more likely to succeed in critically interpreting the data from their investigations (Arnold et al. 2014). However, Enquiry- or Problem-based learning is not easily implemented in a class with close to 200 registered students. Katherine C. Lanigan describes an alternative approach to helping students develop their problem solving skills through adoption and adaptation: method development of experiments from the literature (Lanigan 2008). This method represents a compromise between Enquiry/Problem-base learning and the traditional cookbook laboratory manual and is best suited for the new Pharmaceutical Analytical Chemistry course. Instead of basing the experiments on the scientific literature, the experiment will be based on the pharmacopeia, a compendium of analytical methods, which the students have learned to work with in previous courses of their bachelor education.

During the first laboratory session, the students are assigned a drug and should look through the various pharmacopeias to find the appropriate HPLC method and experimental conditions to perform an assay. The drug assigned contains an active pharmaceutical ingredient (API) as well as impurities (for example Lorazepam, monograph USP 3598 and USP 3602 in the United States Pharmacopeia). The students prepare an outline of the procedure they will follow, based on the pharmacopeia method, for the analysis and get it approved by a teacher. The second laboratory session is dedicated to preparing the samples, standards and mobile phase. In the third laboratory session, the students run the pharmacopeia method. Pharmacopeia methods for APIs and their impurities require efficient separation. The resolution, tailing factor and relative standard deviation should be calculated as required by the pharmacopeia method. The percentage of each impurity in the tablet should be determined. The analysis should be performed completely and correctly, or repeated until satisfactory results are obtained.

Session 4: Introduction of information technology tools in the laboratory: HPLC simulation software

There are many interrelated experimental parameters that will impact the aspect of a chromatogram in HPLC experiments and it is unrealistic, both from a time and equipment perspective, to expect the students to explore them all in the context of a few laboratory periods. Information technology (IT) tools are ideal in this context to allow the students to learn and gain experience about the fundamental principles of chromatography without using too much time, solvent or damaging costly instruments.

There are many e-learning tools to help in teaching chromatography online. One option is the CHROMacademy website (www.chromacademy.com), an e-learning website developed by LC-GC magazine and Crawford Scientific. The CHROMacademy website is filled with information, tutorials, quizzes and webcasts to help in learning. The department of pharmacy already has a license for the use of the site and additionally, a 5 years free license is available for university students and staff, which would allow students to use the website also outside of the laboratory for the whole duration of their studies. However, true interactivity is missing and the website does not really constitute a true simulator which can also provide instant and unambiguous feedback.

Although several HPLC simulators are available on the market, they are often costly and platform specific. A tool commonly used in the industry is “DryLab”, developed by the Molnar Institute (http://molnar-institute.com/drylab/). DryLab is an HPLC optimization tool that predicts chromatograms under a much wider range of experimental conditions than would be possible to test in the laboratory. The software allows the user to vary multiple method parameters, such as pH, temperature, buffer concentration, and many more. Although probably one of the best tool available, the Molnar Institute does not offer a free license to university staff and students, making its cost a hurdle to its use in the teaching laboratory.

Boswell et al. (2013) have developed a free, open-source web-based HPLC simulator designed especially for the education community. Accessible at www.hplcsimulator.org, it is also available as an application for android smartphones and tablets. The simulator features controls for a wide range of experimental parameters and displays a graphical chromatogram to provide immediate feedback to the students. The software therefore offers an attractive alternative to its more costly competitors. With the HPLC simulator, the students can work on an exercise set with in the laboratory where they can get additional help from the instructors. The students also have access to the simulator at home to complete the exercise or review muddy points.

Session 5 & 6: Improvements on Pharmacopeia methods

Based on the experimental results obtained in session 3 and the knowledge gained from the simulations in session 4, the students devise a plan for improving the separation of the drug they have been assigned. The goal can be to improve resolution, shorten analysis time, improve peak shape, etc. The plan should be discussed and approved by an instructor. Discussion with the instructor will allow stressing out that pharmacopeial methods are standards and cannot be modified without validation. However, the pharmacopeia allows for certain adjustments to be made to the procedure. The acceptable range for modifications of HPLC methods without the requirement for validation is detailed clearly in the European Pharmacopeia 2.2.46. Other improvements possible to the method, aside from changing the separation conditions, could involve the construction of a calibration curve and the calculation of uncertainties, which are limited in the pharmacopeial methods but an important aspect of the course. The students should be encouraged by the instructor to construct a calibration curve and compare the results obtained with those obtained using the pharmacopeia method.

Evaluation of the student's performance in the laboratory: The lab report

Two types of evaluations are normally used to evaluate the students' performance in the laboratory. The students either get to write a standard lab report mimicking a scientific paper (introduction, methods, results and discussion, conclusions) or answer a set of post-lab questions. However, both these types of reports can easily become redundant with the material available in the lab manual. When there is a detailed lab manual to support an experiment, writing an introduction and a methods section is often purposeless as the students lack a real research agenda and there is little for them but to parrot back selected details from the manual (Moskovitz & Kellogg 2011). Even when answering post-lab questions, students tend to not share the actual findings from the experiment, but instead use the ones found in books, on the internet or in the lab manual itself (Abidin et al. 2013). It is imperative that student writing be aligned with the lab activity. Method Development can alleviate this problem, as the students cannot just passively recopy the information available in the lab manual, textbook or from the course instructor. There is a real communication purpose behind the lab report, as the students should have substantially altered the standard pharmacopeia protocol and must scientifically justify the changes they made to the reader, who is not merely a grader anymore. However, the introduction section is still a very unproductive piece of work as the students at this intermediate level lack the breadth of knowledge needed to discuss their experiments in the context of the primary literature (Moskovitz & Kellogg 2011). It is therefore preferable to focus on tasks that are more productive to save both the students and instructors some time. Students will eventually get to write a full research report when they do their final pharmacy project. In the pharmaceutical analytical chemistry course, students should focus on a limited number of skills that are essential in science writing: how to decide which data to present, how to use graphs and tables to display their data effectively and how to discuss the presented data (Moskovitz & Kellogg 2011). This will allow us as instructors to request higher quality work and to provide more extensive feedback to the students, as the reports will be shorter. Therefore, the report should contain only a “Methods” section, a “Results & Discussion” section and a “Conclusions” section. The students should be evaluated on whether the data was handled with care and integrity, the clarity of the report and communication skills, and the quality of the results. The reports will be graded with extensive comments and will count towards the final grade of the course.

Handout

An example of the student handout accompanying the new exercise in shownbelow.

Experiment 1 - HPLC

Prior to the experiment:

Literature:

- Pharmacopeia Ph. Eur. 2.2.46
- Harris Chapter 23, 24, 25, 26

Answer the following pre-lab questions:

- Draw a schematic of an HPLC injection loop in the “load” and “inject” positions. How is the sample volume defined?
- How much sample do you need to inject into the loop in order to ensure repeatable injections?
- What are the basic components of a HPLC system?
- What is the difference between “reverse” and “normal” phase chromatography?
- Draw the chemical structures of the active pharmaceutical ingredient as well as the impurities expected in your assigned tablet.

First session:

- Review your answers to the pre-lab questions with an instructor.
- Find the monograph in the pharmacopeia for the drug/vitamin mixture your group has been assigned.
- Prepare a 1 page outline of the experimental procedure to follow in order to perform the HPLC analysis of your assigned mixture. Don’t forget to take into account the number of replicate measurements you will have to do and your mobile phase flow rate to determine exactly how much sample and mobile phase you should prepare.

Second session:

- Prepare your samples and mobile phase.
- Note that you will have to degas your mobile phase for at least 15 minutes in the ultrasonic bath before running the experiment.

Third session:

- Run the separation according the pharmacopeia method.
- Calculate the resolution, tailing factor, relative standard deviation and percent impurities as required by the pharmacopeia method.
- Answer the post-lab questions:
  - What are the charges of your compounds at the separation pH?
  - Determine the amount of API as well as the percentage of each impurity in your tablet.
  - How do the results correspond with the claimed content? Is the tablet compliant?
  - Is the separation ideal?
  - Which aspects of the chromatogram obtained could be improved?
  - What else could be improved?

Fourth session:

- Go to HPLCsimulator.org
  - Draw the chemical structures of the components listed in the default separation mixture.
  - Change the pH/Temperature/solvent strength/particle size and observe the changes in the displayed chromatogram.
- Post-exercise questions
  - How does pH/Temperature/solvent strength/particle size influence separation? Why?
  - Based on what you have learned today, how could you improve the separation of the components in your tablet?
  - Prepare a revised outline of the procedure to improve the separation of your compound mixture.
  - Does your new method require validation?
  - How would you perform a validation?
  - Describe another method you have learned to determine the concentration of each analyte in your tablet, which is different from the method described in the pharmacopeia. Incorporate this to your revised analytical method.

Fifth session:

- Prepare your samples and mobile phase according to your revised analytical method.

Sixth session:

- Run the separation according to your revised analytical method.
- Calculate the resolution, tailing factor, relative standard deviation and percent impurity for your tablet. Report your results with a confidence interval.
- Answer the post-lab questions:
  - Which parameters did you change from the original method?
  - What was the impact of the changed parameters on the separation and why?

Instructions for the laboratory report:

- Your laboratory report should include:
  - A cover page
  - A detailed experimental section detailing the modifications you have made to the pharmacopeia method
  - A results and discussion section presenting your results in a clear and concise manner. Think about which results should figure in this section and what would be the best method (figure, table, etc.) to convey your results clearly to the reader. Discuss the presented data in relation with the theory. Do not forget error bars on your calibration curves and report results with a confidence interval when appropriate.
  - A short conclusion and possibly suggestions for future work and improvements.
  - A list of the cited references (Pharmacopeia methods, text book, websites...)

In summary

The laboratory portion of the Instrumental Analytical Chemistry course (now re-baptized Pharmaceutical Analytical Chemistry) will be modified to reflect current knowledge in teaching education. The number of experiments has been reduced and more time is allotted to the new experiments to allow the students more time for preparation, reflection and experimentation. Elements of Problem/Enquiry-based learning have been introduced in order for the students to be more involved in the design of the experiments, instead of merely following a “cookbook recipe”. The change from a traditional laboratory manual also enhances the value of the laboratory report, as without a manual to copy from, the report is rehabilitated and serves a real communication purpose for the students to present to their instructors what they have done in a clear and concise manner. Information technology tools are also introduced in the laboratory to enhance the students learning experience. The new course will be offered for the first time in 2017, at which point, an evaluation of the outcome of the new teaching methods in the laboratory will be possible.

5

Attempt to increase the learning outcome from laboratory exercises

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Introduction

This year (and hopefully many years to come), I have taken part in teaching a second year Bachelor course in biochemistry (“Biokemi 1”), which is a mandatory or elective course in a number of Bachelor programs (Biology-biotechnology; Food science and nutrition; Animal Science; Natural Resources; Chemistry) at the University of Copenhagen. The number of students taking the course is around 220-240. For my project in “Universitetspædagogikum”, I chose to focus on the laboratory exercises, as it was my impression from the Course responsible and the student evaluations from the previous year that this is where there was room for improvement.

In traditional university chemistry courses, we spend a vast amount of time and resources on practical laboratory exercises, as also highlighted by Wood (1996). Students also spend many hours on the practical part of the courses, as exercises are often mandatory, and reports have to be accepted – possibly as a prerequisite for taking the course exam. Reid & Shah (2007) states that “*the labour costs for 3 hours of laboratory teaching may well be around 15 times the costs for a one hour lecture for 100 students. Is the learning gain 15 times greater?*”. I don’t think the equation is as easy as to only look at the learning gain, as it is also a matter of learning aims. In my mind though, the important question is if it is possible to increase the learning outcome from these exercises, as the time spend not always seems to result in an adequate learning outcome.

I find it very motivating to work with this subject: how to increase the learning outcome from practical laboratory exercises, which was also the topic for the pre-project "Learning from Lab Work", that I conducted together with four other participants of this course. In this pre-project we interviewed 7 students about their experiences with laboratory exercises, and some of the recommendations were to have laboratory manuals as open as possible, to have clear aims, to "force" the students to prepare something before the exercises – all means to increase the learning outcome. Furthermore, it was recommended to repeat the theory in different ways, and to prioritise time to ask questions to the students and create "discussions" between students and teachers. Finally, it was emphasised that "less is more", meaning that the students would prefer fewer exercises, or exercises with less information, where they could actually grasp the essential aims of the exercises, rather than an overload of information and exercises.

For the Biochemistry 1 course, I was assigned to be responsible for one of six laboratory exercises. My exercise ran parallel with another exercise during the first two weeks of the block (in total, the exercise was conducted 10 times during these two weeks, with approximately 24 students each time). The exercise "Ion exchange of ribonucleotides" was allocated 4 hours, as for all the laboratory exercises. The exercise usually takes 3-4 hours to conduct, and it was not possible to allocate extra time. I had no prior experience with teaching this exercise, so the changes I made were only based on my personal experiences with the exercise, the pre-lab questions and the report scheme that is to be handed in. It was not possible to change the exercise itself, neither the laboratory manual. Therefore, I chose to make some changes in connection with the theoretical preparation for the exercise, and I decided to use 30-45 minutes in the beginning of the practical exercise. Here, it was my plan to have a short theoretical session before starting up in the laboratory. I chose to do this, as it is my impression that students often use most of their energy in the laboratory focusing on conducting the experiment as described in the manual. They are not focusing on the part of learning from the exercise while being in the lab. My focus was to try to move the learning into the lab, thereby also possibly raising the motivation and increasing the learning outcome.

Method

I decided to add some extra theory about the analysis methods that are being used in the exercise (ion exchange chromatography and UV spectroscopy), as well as moving some questions from the report scheme to the pre-lab questions. My idea with having a theoretical session before the practical exercise was to have students actively participating in a discussion about the choice of methods for the exercise. I chose to do this because I wanted to engage, and increase the interests of, the students in order to enhance their “intrinsic” motivation and thereby increasing deep learning (Biggs and Tang, 2007).

In the exercise, a mixture of four nucleotides is separated by use of ion exchange chromatography, and following identified using UV spectroscopy. The added pre-lab questions concerned the structures of the nucleotides (own drawings and identification of groups responsible for acid/base characteristics) and drawing of Bjerrum-diagrams for the four nucleotides.

The theoretical session took place in an empty laboratory, with only a small blackboard. My intention was to have a dialogue with the students by raising some questions concerning the practical exercise, but related to the theoretical understanding. The questions I prepared to use for the dialogue were:

- What kinds of column chromatography do you know?
- Could we have used any of these to separate the nucleotides, and why/why not?
- Could we use both cation exchange and anion exchange chromatography?
- At what pH do we apply the sample? And at what pH can we expect the nucleotides to elute?
- How can we detect that we have compounds eluting from the column?
- Should we measure UV at 254 nm or 280 nm?
- How can we use UV to identify the different nucleotides eluting from the column?

And some more practical oriented questions as:

- How do you apply the sample to the column?
- Why is it important to wash with water before elution?

With these few changes, I hoped that the students would gain a greater understanding of the exercise while doing the actual exercise in the laboratory, thereby also achieving a deeper learning of the theory over time. With the additional theoretical introduction, it was my wish to draw more focus on the methods used, as it is the methods that – in my view – are the most important learning outcome from the exercises at this point of time in their education (second year).

The theoretical session was introduced on 3 days during the second week, and it changed somewhat over these days. The first day (Thursday), it took approximately 25 minutes, and was mainly a theoretical session as described above. The session included 5 minutes at the end, where I gave some practical information, in the same way as I would usually do in the first 5 minutes of the practical exercise. As the students following were as confused as without the theoretical session (due to an insufficient description of the experimental setup in the laboratory manual, and a lot of unknown equipment), I decided to extend the session the following day (Friday, 35 minutes). I brought an experimental setup and at the end of the session I went through all the equipment and explained what it was and how it should be connected etc. This seemed to have a slightly positive effect on the following start-up in the laboratory, though there was still a lot of confusion. On Monday, I further extended the presentation with the drawing of a workflow on the blackboard, in order to illustrate how different tasks could be initiated at the same time, and what tasks should be done at which point. This Monday, the session went on for approximately 45 minutes.

All students who had been exposed to my extra theoretical session were given a questionnaire the following week in the laboratory. I chose to hand out the questionnaire the following week, because I wanted the students to have had time to do the reports (where they work more with the theory) before filling out the questionnaire. The questionnaire comprised 13 questions (see Appendix).

Results

It was easy to see that the students were not used to partake in a dialogue. Most students seemed uninterested in the beginning, and it became more difficult to obtain a dialogue, than I had expected. Some students stated that they had not solved the pre-lab questions as they did not know how to. Instead of creating a dialogue with all the students, I asked them to discuss a question in smaller groups. This seemed to create more activity and discussion about the question, and more students were afterwards willing to come up with an answer. The sessions never reached a point where the students came up with a lot of questions themselves. This can be interpreted in different ways. The questions and theory might have been too easy and too obvious, or the students were not puzzled enough about the theory, in order to seek answers to questions.

The results from the questionnaire can be found in the Appendix. Overall the students responded positively to the theoretical session, but approximately half of the students found that we spend too much time on this session. Around 40 % of the students answered that they had only done part of, or none of, the pre-lab questions. These questions were quite central for the theoretical session, and I did not spend time going through these as it would have further prolonged the time spend on the theory. Additionally, it was not until I received the questionnaires, that it became clear to me, how many might have had a lacking foundation for the theoretical discussion. This, of course, can to some extend explain the unwillingness to participate in discussions, but I also think it is a matter of what the students are accustomed to, or not, from earlier courses.

Approximately 2/3 of the students found that they had a better theoretical understanding of the exercise after the theoretical session (see figure 5.1 and Appendix) compared to the other practical exercises they had conducted. This result from question 8, and the results from the following questions 9-13 (see Appendix), are difficult to evaluate, as I do not have results from those students who did not have extra theoretical session. It would have been valuable though if I had given questions 8-13 to all students, as this could have shown a possible effect from the theoretical introduction.

According to my own observations from the laboratory exercises, the theoretical session did not seem to influence the way the students worked in the laboratory afterwards. They were still confused about the unfamiliar equipment, and the insufficient manual description of how to start up the experiment still caused the same amount of questions asked, even on those days when I had given a more thorough introduction to the practical work (i.e. Friday and Monday). As my main aim with the session was to increase the theoretical understanding, this observation should not be given too much focus. A better theoretical understanding could be expected to have a positive effect on the report schemes, but when judging from the report schemes that were handed in from the students, I could not see any positive effect, rather a negative effect could be seen (based on how many reports were approved in the first round).

The students seemed positive about my initiative with the theoretical session before the laboratory exercises, even though they did not actively participate as much as I had hoped for. I am not convinced, though, that it had a positive effect on the theoretical understanding. This observation

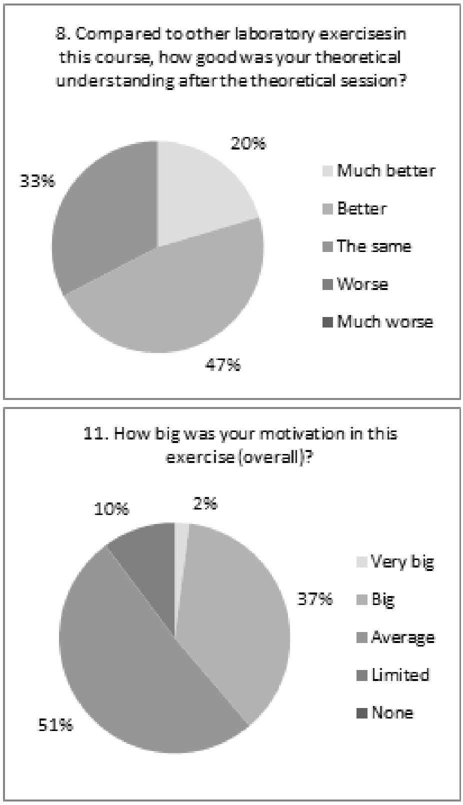


Fig. 5.1. Results from question 8 and question 11 – see Appendix.

is solely based on my judgment of the report schemes. In order to assess the effects properly, I should of course have given a short questionnaire to all students – not only to those having the extra theoretical session. And it would also have been valuable to assess the deeper theoretical understanding with a few questions, i.e. one month after the exercise. This would have given a better basis for the following discussion.

My hypothesis was that I could motivate the students and increase their learning outcome by giving them some tasks and information before going into the laboratory and conducting an exercise. I knew from my pre-project that the students actually appreciate to have pre-lab questions, and also want to be “forced” to think about, and discuss, the relevant theory. I wanted the students to understand some of the theoretical basis for how the experiment was designed (i.e. why is pH important?), and also to give them an understanding for the chosen methods, by guiding them with questions (i.e. why do we use ion exchange chromatography and not affinity chromatography or gel filtration chromatography?). More than 1/3 of the students felt motivated above average (see figure 5.1 and Appendix). My impression was that this did not result in more motivated students, when compared to those days without the theoretical session. This is based on the observation in the laboratory, where I think more motivation would result in more questions concerning the theory. But on the other hand, if the theory is clearly understood, then the lack of questions might not mean a lack of motivation.

Discussion

It is broadly accepted (according to the theory of constructivism) that in order to create new knowledge we need to build on what we already know (Biggs & Tang 2011*b*). Schwartz & Bransford (1998) talk about a “time for telling”, or as they also put it, “a “readiness” for being told something”. This point arises i.e. when we enter a learning situation with a lot of background knowledge, and a clear sense of the problems for which we seek solutions. However if we do not have any prior knowledge, new information will be memorized rather than being used to help the perception and thinking (Schwartz & Bransford 1998). From an experimental setup (see figure 5.2) Schwartz & Bransford (1998) conclude that providing students first with an opportunity to work actively with i.e. data, followed by a theoretical explanation as i.e. a lecture, provides the right setting for a deep understanding.

This implies then, that it might not be the most optimal setting to give the students a theoretical setting before working actively with the subject. On the other hand, by giving students pre-lab questions, we try to create some knowledge to be built upon. But this does not seem to create enough background knowledge to create the right setting for a “time for telling” (that is an optimal situation for deep learning) in the laboratory.

With reference to Schwartz & Bransford (1998), I think we should rather think of the importance of giving a theoretical session **after** the laboratory exercise, instead of before, as I have tried it in this setup. As I have also heard in a talk about teaching and learning, we need to make students

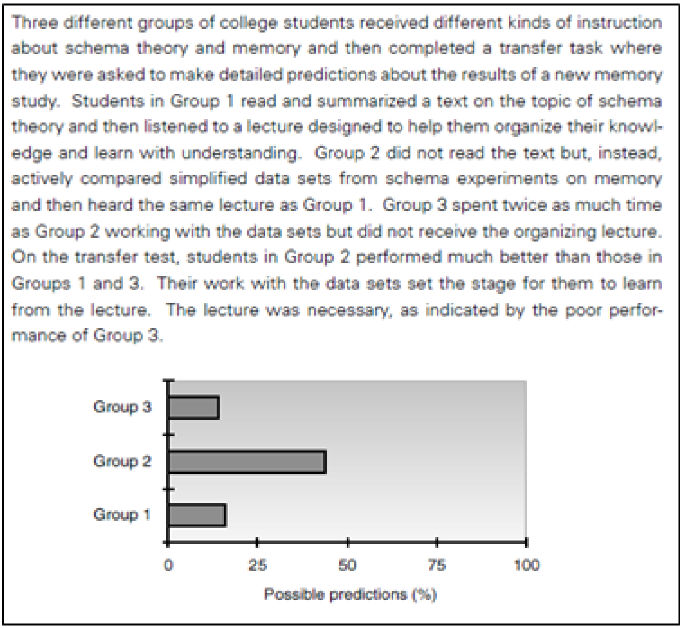

Three different groups of college students received different kinds of instruction about schema theory and memory and then completed a transfer task where they were asked to make detailed predictions about the results of a new memory study. Students in Group 1 read and summarized a text on the topic of schema theory and then listened to a lecture designed to help them organize their knowledge and learn with understanding. Group 2 did not read the text but, instead, actively compared simplified data sets from schema experiments on memory and then heard the same lecture as Group 1. Group 3 spent twice as much time as Group 2 working with the data sets but did not receive the organizing lecture. On the transfer test, students in Group 2 performed much better than those in Groups 1 and 3. Their work with the data sets set the stage for them to learn from the lecture. The lecture was necessary, as indicated by the poor performance of Group 3.

Fig. 5.2. Based on the results from experiment 3 in Schwartz & Bransford (1998), as presented in Bransford et al. (2000).

curious before they are ready to learn. In a laboratory setting, I think this could be done by focusing less on the theory in the introduction to each exercise, and maybe trying to make some of the steps during the practical exercise more open (according to what level the students are on, the level of openness should be adjusted) as also argued by (Tamir 1989). The important point is then, that after creating this momentum of “confusion” or curiosity, we need to provide a theoretical frame where the students can construct new knowledge by building on their experiences and observations in the laboratory. To some extend one can argue that this is already done in the form of the laboratory reports, but I don’t think this is a sufficient tool to generate the deep learning from the exercise that we intend to give the students.

My focus has been how to increase the learning outcome from laboratory exercises, and aside from thinking in the line of the changes in the way the theory is presented to students (before or after a practical exercise), other points can also help to increase the learning outcome for the students. Reid & Shah (2007) points to the lack of clear aims in many laboratory manuals, where there is too much emphasis on the experiments to be performed and not enough emphasis on what the students should be gaining. This is an argument also highlighted by (Wood 1996), who furthermore writes that we should examine the motives for having students carrying out practical laboratory exercises. He also argues that in the early years of the university education, it would be preferable to separate some of the processes and skills we are trying to give the students, and as a progression during a course, finalise with an open-ended research project that demands a competently use of these skills (Wood 1996). Reid & Shah (2007) also underline the importance of pre-laboratory exercises as a mean to reduce the information overload on students (see figure 5.3), thereby also increasing their learning outcome. Reid & Shah (2007) also emphasise the importance of post-laboratory tasks, but has only few comments on what these could comprise, and not in the form of a lecture or similar way of giving a theoretical frame for the students.

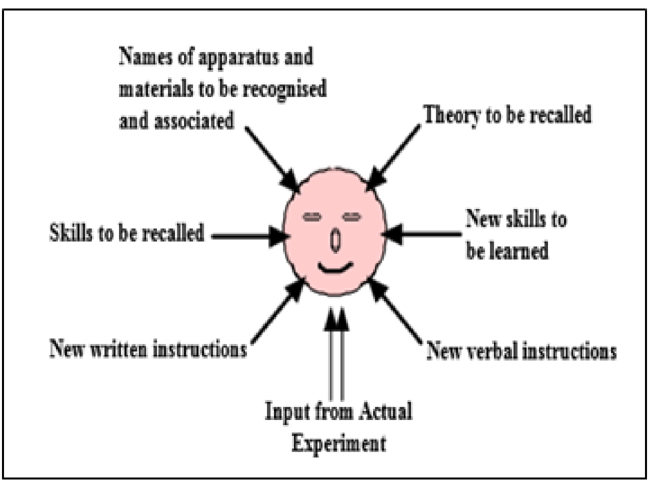


Fig. 5.3. Sources of information for students in undergraduate laboratories (Reid & Shah 2007).

Table 5.1. Laboratory practical work can develop skills and illustrate lecture (or textbook) content. The example chosen here is an enzyme assay (from (Wood 1996)).

Illustrates lectures	*Lab skills developed*
Enzyme catalysis demonstrated	Use of pipettte, spectrophotometer, understanding how assay is carried out
Enzymes are labile	Repeatability—only good if enzyme stored properly
Properties depend on conditions (pH, temperature)	Planning how to carry out assay (choosing appropriate conditions)
Form of kinetic curves	Manipulating data, deriving kinetic curves
Types of inhibition	Analysis of kinetic data

But what should the pre-lab questions then comprise of, in order to optimise the learning outcome? Reid and Shah (Reid & Shah 2007) writes that the aim of the pre-lab questions is to “prepare the mind for learning”, by i.e. stimulating the students to think, encouraging them to recall or find facts, check the understanding of the experimental procedure, leading the students to thinking about the procedure and concepts etc.

With Schwartz & Bransford (1998) in mind, I would give more focus to the post-lab activities in the future when I have to plan the exercises in Biochemistry, as I didn’t find the pre-lab questions and theory session useful enough for creating a deep learning of the matter intended. This does not mean that pre-lab questions are not justified, but should maybe be revised with a clear aim of the exercise in mind. This also applies to the laboratory manual itself, where the aims i.e. could be illustrated as shown in table 5.1. Furthermore, I would like to give more focus to the report schemes and the way they are evaluated (more formative than summative), maybe in another setup than the existing, where reports are returned with written comments and no oral feedback is given. But if the best “time for telling” is after the students have worked with the subject, then why not try to change the way we “teach” laboratory exercises, and focus on giving a theoretical frame after the exercise.

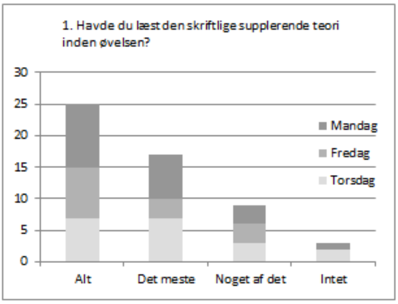
Concluding remarks

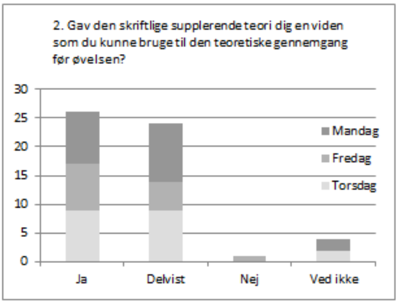
How we learn and how we as teachers can increase the learning outcome for the students in any given situation is in my opinion interesting to work with. In this project I have made an attempt to increase the learning outcome from a laboratory exercise, by having a theoretical session with the students before the practical laboratory exercise. The students responded positive to the initiative, though they also commented that the time spend was too long. I did not notice any clear positive effect with regard to motivation (more questions asked) or theoretical understanding (based on report schemes) after the theoretical session.

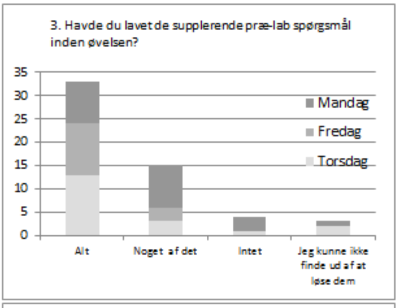
In the future, I would like to revise the laboratory manual, with clear aims in mind, as illustrated in table 1, where connection lines are drawn to the lectures, and practical skills are highlighted. Furthermore, I would like to see if it is possible to have less theory as introduction to the exercise, and maybe instead have the theory somewhere else, so we can make the students ready for the information before giving it to them ("time for telling"). I would also like to look into the possibilities for at post-lab session, either on the same day of the exercise, or the following week. In line with this, I also want to work with the report schemes and the way we evaluate the reports, which I would like to turn towards a formative evaluation rather than a summative. Both with respect to evaluation and post-lab session, with 220 students conducting the same exercise at 10 different 4 hour sessions, it is important to keep the practical aspects in mind, though they should not be an excuse for what is possible or not possible.

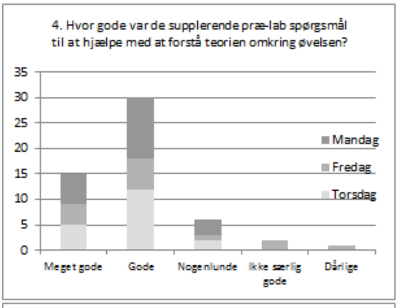
Appendix

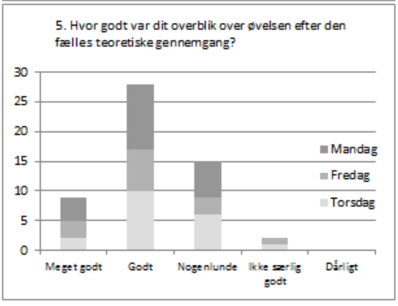
For all results below, the y-axis is the number of students.

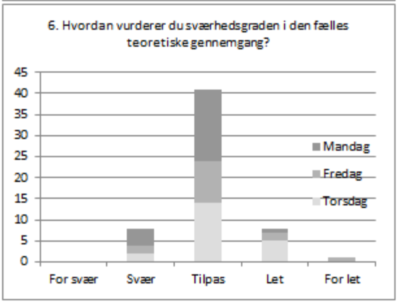


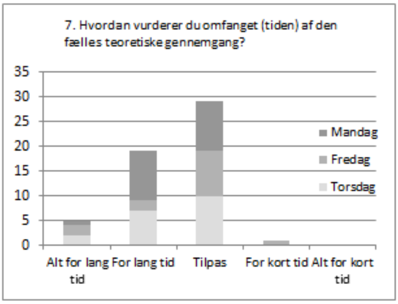


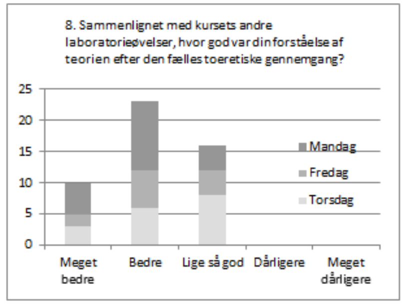


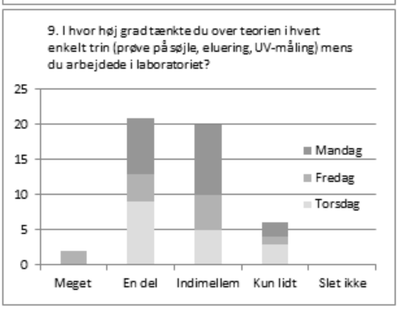


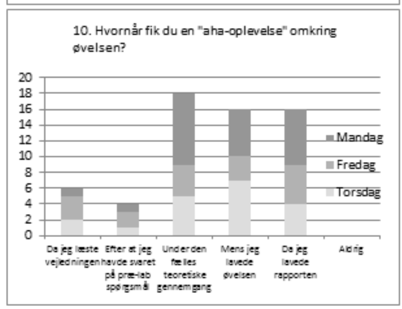


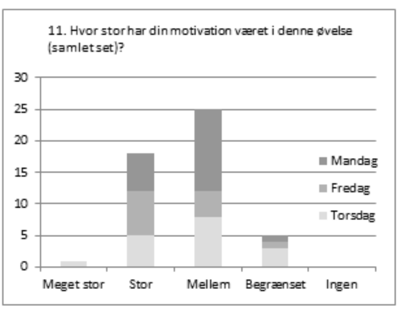


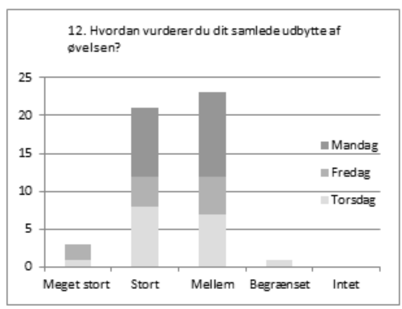

7. Hvordan vurderer du omfanget (tiden) af den fælles teoretiske gennemgang?
35
30
25
20
15
10
5
0
Alt for lang tid
For lang tid
Tilpas
For kort tid
Alt for kort tid
Mandag
Fredag
Torsdag

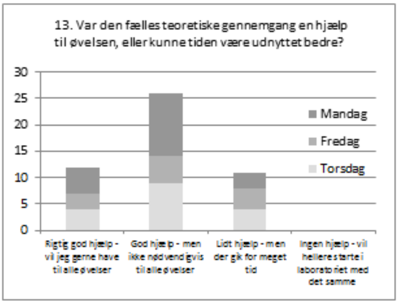

8. Sammenlignet med kursets andre laboratorieøvelser, hvor god var din forståelse af teorien efter den fælles toeretiske gennemgang?
25
20
15
10
5
0
Meget bedre
Bedre
Lige så god
Dårligere
Meget dårligere
Mandag
Fredag
Torsdag

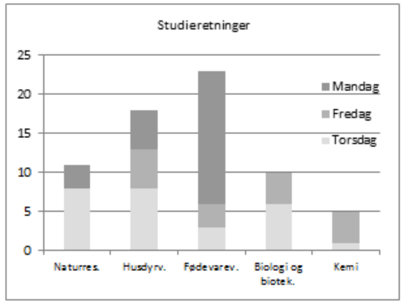

9. I hvor høj grad tænkte du over teorien i hvert enkelt trin (prøve på søjle, eluering, UV-måling) mens du arbejdede i laboratoriet?
25
20
15
10
5
0
Meget
En del
Indimellem
Kun lidt
Slet ikke
Mandag
Fredag
Torsdag


10. Hvornår fik du en "aha-oplevelse" omkring øvelsen?
20
18
16
14
12
10
8
6
4
2
0
Da jeg læste vejledningen
Efter at jeg havde svaret på præ-lab spørgsmål
Under den fælles teoretiske gennemgang
Mens jeg lavede øvelsen
Da jeg lavede rapporten
Aldrig
Mandag
Fredag
Torsdag


11. Hvor stor har din motivation været i denne øvelse (samlet set)?
30
25
20
15
10
5
0
Meget stor
Stor
Mellem
Begrænset
Ingen
Mandag
Fredag
Torsdag


12. Hvordan vurderer du dit samlede udbytte af øvelsen?
25
20
15
10
5
0
Meget stort
Stort
Mellem
Begrænset
Intet
Mandag
Fredag
Torsdag





Comments:

<u>Thursday: (19 out of 25 possible)</u>

- I stedet for pre-lab-øvelser som i forvejen var en del af rapporten, var det måske bedre at erstatte opgaverne ét af stederne med andre opgaver.
- Måske unødvendigt, at det samme skulle tegnes i præ-lab, som i rapporten bagefter.
- Fælles teoretisk gennemgang kunne godt have indeholdt mere introduktion til selve udførelsen af forsøget - da det var svært, og øvelsesvejledningen var lidt forvirrende.
- Syntes det er en super idé med mere teoretisk stof i øvelsesvejledningen, men gennemgangen var lidt for lang, så det endte med at blive lidt kedeligt men det er et super initiativ :).

<u>Friday: (14 out of 14 possible)</u>

- Super gennemgang
- Synes det fungerer godt at snakke om tingene og få afklaring på det man ikke forstod i øvelsesvejledningen
- Den teoretiske tid skulle have været mere konkret, fortæl enkelt hvordan principperne skal forstås og lav en naturlig gennemgang af hvert trin. Jeg blev forvirret fordi det tog så lang tid.

<u>Monday: (21 out of 24 possible)</u>

- Den fælles teori var god men forsøgene skal afpasses hvis det bliver en regulær ting, da der næsten ikke var tid nok til forsøget.
- Det var godt med flow-sheet og fremvisning af udstyret. Ideen er rigtig god, men 45 minutter er meget lang tid og tiden kunne have været brugt

bedre, da jeg startede med de “samme problemer” jeg havde tænkt jeg ville støde på selvom teorien blev gennemgået.
- Fælles gennemgang var super godt, det tog bare lidt for lang tid, så vi havde svært ved at nå at udføre hele forsøget.
- Det var dejligt at mærke at du var så meget tilstede i laboratoriet. Det er lækkert at du gik rundt og fulgte op på hvor langt vi var, og om der var noget vi skulle have hjælp til.
- Jo mere fælles gennemgang og vejledning - jo bedre!

Fungi are characterized how...?

6

Fungi are characterized how...? Implementing inquiry-based learning in a laboratory exercise.

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Section for Organismal Biology, Department of Plant and Environmental Sciences, University of Copenhagen

Introduction

Laboratory exercises have great potential for conveying scientific principles, for development of critical thinking skills and for fostering deep learning. A common misconception of laboratory exercises is that their teaching potential is intrinsic —that students engaged in activity or hands-on learning are by default learning as intended (National Research Council Committee 2000). More accurately, the teaching potential of laboratory exercises is highly dependent on how the activity is designed and how the information is conveyed.

In traditional pedagogics, laboratory exercises use kit-based or cookbook approaches where students simply follow a recipe and record data. Students usually proceed through such a predefined and rigid exercise without a clear understanding of the purpose behind each step (Hofstein & Lunetta 2003). These cookbook exercises represent a type of direct instruction method where the laboratory manual or teacher lays out a set of prescribed activities with no possibility for independent thinking. An inherent problem with direct instruction is that it leaves little opportunity for problem-solving and higher-order critical thinking skills, both of which are implicated in deep learning, knowledge retention and development of scientific inquiry skills (Halme et al. 2006, Biggs & Tang 2011*a*). Direct instruction education may result in an accumulation of knowledge but it does not necessarily lead to a firm grasp of the topic or key concepts nor does it lead to skills development.

Among the first to acknowledge the limits and drawbacks of direct instruction pedagogy was John Dewey. Dewey wrote extensively on the philosophy of education and on the theory of inquiry (Dewey 1938). He was a pioneer of and major advocate of inquiry-based learning.

> "Before 1900, most educators viewed science primarily as a body of knowledge that students were to learn through direct instruction. Dewey contended that science teaching gave too much emphasis to the accumulation of information and not enough to science as a way of thinking and an attitude of mind. Science is more than a body of knowledge to be learned," (National Research Council Committee 2000, p. 14)

Inquiry-based teaching is a pedagogical method that promotes learning by guiding the student toward the resolution of a problem or problems. In inquiry-based teaching the instructor serves as a facilitator rather than a mere deliverer of information. The student, in collaboration with their fellow student(s), observes, hypothesizes, investigates, interprets, shares authority for answer(s) and as a result, is empowered to ask additional questions. This is in stark contrast to the traditional teaching method where students routinely memorize information and complete specified tasks and where the authority for answers remains solely in the teacher's court. Inquiry-based learning is best represented as a cycle (Figure 6.1) which involves questioning, investigation, project creation and cooperative learning through discussion and reflection. A central tenet of inquiry-based learning is that this cycle is continuous and that successful inquiry leads to the ability to ask more questions (Koschmann 2013). This cycle can be used as a basic model for designing inquiry-based laboratory exercises.

Inquiry-based learning is a successful strategy that has been shown to significantly improve performance on assessment questions (Rissing & Cogan 2009). Despite its success and promise, inquiry-based teaching remains more of an alternative teaching method rather than the standard in educational institutions (Brainard 2007). One of the reasons that inquiry-based teaching is not more prevalent is because it is thought to be too difficult to implement. In addition, there is a misconceived notion that the principles of scientific inquiry and inquiry-based learning are only applicable to the discipline of science.

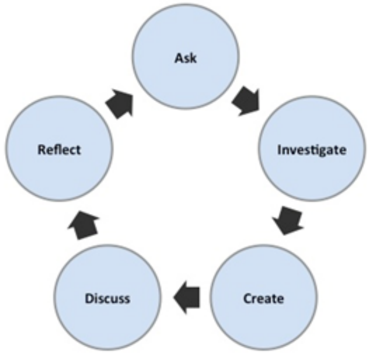


Fig. 6.1. The cycle of inquiry based learning. (adapted from http://chipbruce.net/resources/inquiry-based-learning/defining-inquiry-based-learning/)

Project Description

The purpose of this project is to implement inquiry-based teaching to the Masters level course *Biological Control of Pests* (5440-B2-2E14) which is taught annually at the Department of Plant and Environmental Sciences at the University of Copenhagen. The course, *Biological Control of Pests*, is run by a single professor; however, additional professors as well as post-docs and PhD students participate in teaching several of the exercises and lectures.

This project focuses on the revision of one laboratory exercise, *Characterization of Fungi*, which was previously taught by other post doctoral researchers and instructors other than myself. The objective of the exercise, *Characterization of Fungi*, is to demonstrate what can be discovered about insect pathogenic fungi through molecular characterization, i.e. DNA sequencing and analysis. In past years the exercise followed a strikingly traditional, cookbook format with no opportunity for inquiry or for critical thinking; it was setup so that students are given an unknown fungus and over two course days are instructed to extract, amplify and sequence its DNA by following a very specific set of mostly kit-based instructions. As the exercise is, the students largely experience the tedium of kit-based instructions rather than excitement of inquiry and hypothesis testing.

Two goals in revising this exercise are to turn it into a more accurate representation of how an insect pathologist would characterize a fungus in their everyday research — a process that is naturally inquiry-based, and to include inquiry-based activities for teaching the principles of not only the topic *Characterization of Fungi* but also the principles behind the methods. The purpose of the later is to equip the students with methodological problem-solving skills, which are as much a part of scientific inquiry and inquiry-based learning as are hypothesis formulation and hypothesis testing.

Implementation

One of the difficulties in improving *Characterization of Fungi* is that the main focus of the exercise, molecular characterization, from start to finish is very time-consuming yet the entire exercise must be completed in two, short, four-hour course days. In previous years, both course days have run over the allocated time. In redesigning the exercise I opted for quality over quantity, for removing activities, e.g. kit-based activities, or steps with low teaching potential and with a correspondingly inefficient use of time. These steps, although not omittable in everyday research, were viewed as an impediment to the incorporation of problem solving or critical thinking activities. The primary goal of my project, to make the exercise inquiry-based was partly achieved by presenting the students with a real-life problem that could be solved through guided steps and collaboratively with their classmates.

Part1. Problem formulation and setting the stage for inquiry

With the extra time afforded by the exclusion of the kit-based exercises I was able to include a morphological component which in turn set the stage for the entire exercise. The addition of the morphological component made the exercise more true to the day-to-day experiences of an insect pathologist in biological control (the course topic); as a result the steps and premise of the exercise were more logical than in the pre-revised exercise. This morphological component included unknowns which served to formulate the initial problem and which formed the basis for subsequent activities.

Part II. Stimulating inquiry with unknowns

Traditionally, morphological characterization in a laboratory exercise involves making guided, step-by-step observations of the organism whose identity is given. I avoided direct instruction by designing the exercise so that the students were presented with five unknowns and provided with the tools, e.g. guided observation and a dichotomous key, to identify the unknown organisms. The students were instructed to first individually record their basic observations for each unknown and then work in groups of three or four. By including unknowns that now essentially belonged to the students, the problem became a tangible one and promoted further inquiry and curiosity. *Were their identifications correct? What would the molecular data reveal about the fungus they observed, described and identified earlier?* (see Appendix A)

Part III. Exercises for the exercise: implementing short inquiry-based activities for teaching the principles behind the methods.

Laboratory exercises all require the inclusion of a step-by-step instructional part at some point. In *Characterization of Fungi* the step-by-step instructional component was reached at the end of the first day in the molecular characterization section. To encourage the students to think about the steps and to understand the principle behind the methods I developed two short inquiry-based exercises for them to include in the step-based experimental setup (see Appendix B). The students were asked to come up with two hypotheses, which were subsequently tested in the process of following the cookbook protocol. To be able predict the outcomes or formulate the hypotheses the students had to first grasp the basic principle behind the methods. In contrast to previous years, the step-by-step section in this revised exercise purposely left open the possibility for negative results and failed experiments. These negative results and failures were subsequently discussed as a class and used to enrich the learning experience.

Part IV. Metacognition: the application of learning

On day 2, the laboratory exercise ended with several questions, some of which were open ended. The purpose of these questions was to give the students an opportunity to reflect on the exercise and their results and to discuss their thoughts and solutions with their classmates. In addition, two homework questions were given (see Appendix C). The purpose of the homework assignment was partly to encourage metacognitive thinking. The question posed in the homework assignment required the students to integrate the knowledge gained from the current exercise with the knowledge gained from previous lectures and exercises in the course. The question describes a real-life problem for which the students could now propose an educated solution. The answer to this question could be unique; it relied on the accumulation of knowledge and had no predefined right or wrong answer. The goal was that the students felt ownership for the answer and became aware of their accumulated knowledge.

Conclusions

The successes and benefits

Designing a laboratory exercise with inquiry-based teaching is undoubtedly more laborious than simply providing a list of tasks for the students to complete; however, the benefit of teaching through inquiry is that the students appeared to remain clearly engaged and enthusiastic over both course days. Students asked thought-provoking questions and initiated discussions with their classmates as well as with me. I found the role of facilitator rather than deliverer of knowledge more rewarding and more interesting. In addition, the students provided thoughtful, intelligent answers to the homework questions. It was clear that they grasped the concepts and made connections between this exercise and previous work in the course.

A summary of the key inquiry-focused differences between the original exercise and the inquiry-based exercise is provided in Table 6.1. Overall, the goal of the project was achieved. Inquiry-based teaching in the laboratory exercise Characterization of the Fungi was successfully implemented.

The challenges

Implementing inquiry-based teaching successfully has its challenges. One such challenge is estimating how much time to allocate for the inquiry-based activities. For instance, even though I omitted some of the activities from the original exercise, the revised exercise exceeded the time slot on both days by 10–15 minutes. Inquiry-based exercises requires a lot of time. The limitation of time presents another challenge —filtering the information: if quantity is exchanged for quality, what should be included or omitted? On what activity should the time be focused and why? How can inquiry-based learning of the methodology be incorporated?

Table 6.1. Comparison of the characteristics of the standard protocol from previous years and the newly implemented inquiry-based protocol for the exercise *Characterization of Fungi*.

Characteristic	Standard	Inquiry-based
Problem formulation	**Yes** (provided by teacher)	**Yes** (partly conceived by the student)
Hypothesis testing	**No**	**Yes**, more than once
Independent observation	**No**	**Yes**
Attention to the concepts behind the methodology	**No**	**Yes**
Number of questions posed	**0**	**29**
End assignment a written report of results and methods	**Yes**	**No**
End assignment an open-ended question with a clear link to the knowledge gained from previous lectures and exercises in the course	**No**	**Yes**
Student ownership of answers to problems	**No**	**Yes**
Trouble-shooting skill development	**No**	**Yes**
Critical thinking exercises	**No**	**Yes**
Group work	**Yes**	**Yes**
Collaborative problem-solving built into exercise	**No**	**Yes**

A Appendix I

[Truncated excerpts from day 1 of Characterization of Entomopathogenic Fungi laboratory manual. Pedagogic focus: problem formulation, setting the stage for inquiry with unknowns.]

This laboratory exercise is divided into two parts.

- In the first part of the exercise you are going to identify the fungi from infected beetle larvae, flies and bees. The goal of this part is for you to observe the fungi and become familiar with them. By the end of the exercise you should be able to:
  - recognize the genera *Cordyceps (Beauveria), Metarhizium*, an entomophthoromycotan fungus and a bee infected by *Ascosphaera*
  - identify a spore discharge setup and if spores from an entomophothoromycotan fungus have been discharged onto a slide
- In the second part of the exercise you will test if you have correctly identified the fungus you chose as *Cordyceps* and determine it species by amplifying its DNA and then analyzing the sequence.

– –

Part 1. Morphological Characterization

Here you will learn to recognize members from each of the three of the major groups of insect pathogenic fungi: Entomophthoromycota, Hypocreales, Ascosphaerales. This part is titled morphological characterization but this is a bit of a misnomer because the dichotomous key below includes couplets that rely on ecological characters, on host identification, and on the method of spore discharge. In insect pathology these characters can be just as important as morphological characters and are very useful for narrowing down which fungus you have.

There are 4 fungi for you to identify

Work in groups of 2–3. Before you begin preparing slides write down a brief description of each fungus in the spaces below. Be sure to record your observations in the space that corresponds to the fungus you are looking at e.g. *Fungus 1* observations in the *Fungus 1* space

Prepare a slide for each of the 5 fungi. Divide the work up among your group members.

1. Add a small drop of water to a microscope slide.
2. Pick up a small amount of the fungus from the insect.
3. Place the fungus in the water droplet on the slide.
4. Place a coverslip on top.

Fig. 6.2. Appendix I - (continued)

Fungus 1	
Macroscopic observations: Host/substrate: Color of culture: N/A Color of spores: Forcible spore discharge?	**Draw what you see in the microscope.**
Fungus 2 …	

Dichotomous key

1. Host a fly..2

1. Host not a fly or host unknown...3

2. Conidia forcibly ejected, spade shaped, large.... *Entomophthora muscae*

2. Conidia not forcibly ejected, spherical, small...... *Cordyceps* (*Beauveria*)

3. Host a bee larva, larva mummified, black; spores in sporeballs......................
.. *Ascosphaera aggregata*

3. Host not a bee, isolated from soil 5

4. Conidia cylindrical, formed in parallel chains....................*Metarhizium*

4. Conidia spherical, not formed in parallel chains ....
.. *Cordyceps* (*Beauveria*)

Record your identification for each of the 5 fungi.

Fungus 1 = ____________________

Fungus 2 = ____________________

Fungus 3 = ____________________

Fungus 4 = ____________________

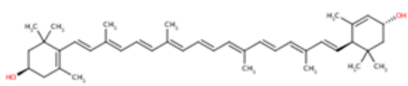
Fungus 5 = ____________________

B Appendix II

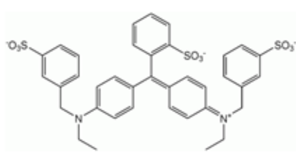
[Excerpts from day 2 of Characterization of Entomopathogenic Fungi laboratory manual. Pedagogic focus: implementing short inquiry-based activities for teaching the principles behind the methods.]

Brief exercise on gel electrophoresis.

In one of the lanes on each gel I added 5 μl of green food coloring. This food coloring is composed of two molecules: Lutein (a plant derived yellow pigment) and Brilliant Blue (a synthesized pigment). The molecules are pictured below. Which of these molecules do you predict will travel faster in the gel? Why? Write down your hypothesis in the blue box on the next page.



Lutein



Brilliant Blue

Fig. 6.3. From: Brief exercise on gel electrophoresis

Hypothesis :

Results : Which molecule traveled further?

Conclusion : Was your hypothesis supported? If not, offer an explanation for your results.

1. Identify the denaturing, annealing and elongation steps in the PCR you are running.

PCR Conditions			
Machine/Program:	*T-gradient Nicolai/ Touch B2*		
TD-PCR			
98°C	30 s		
98°C	10 s		
70–60°C	30 s	**10 x**	reduce temperature by 1°C per cycle for 10 cycles
72°C	30 s		
98°C	10 s		
60°C	30 s	**38 x**	
72°C	30 s		
72°C	10 min		
10°C	4-ever		

Fig. 6.4. Appendix II. (continued)

2. In the PCR you included a DNA extract from Ascosphaera. Do you expect this DNA to be amplified? Why or why not?

C Appendix III

[Excerpts from day 2 of Characterization of Entomopathogenic Fungi laboratory manual. Pedagogic focus: metacognition.]

Answer the following questions in class.

1. Identify the major groups on the tree. Look at the Excel sheet. The groups are color coded. In which group does your fungus belong?
2. Base on the features of other isolates in the group that your fungus belongs to, what can you predict about the isolate you have?
3. What does the sequence data tell you that you would not have known based on morphological features alone?

Work on questions A) and B) below at home. You may work in groups. Post your answer in Absalon.

A). In Lecture 2 of this course you learned about the beetle *Melolontha* that causes damage to the roots of christmas trees. Suppose that these twelve isolates of *Cordyceps* from the previous steps (i.e. Excel sheet) were all collected from a christmas tree farm. If you wanted to develop a biological control product for *Melolontha* from these isolates which group of isolates would you begin screening from? In a paragraph or so, explain what you would do and why. Think about where you would apply the biocontrol product. Would you mix it in with the soil or would you apply it to the above ground parts of the tree? Think about where the target pest lives. Would you consider UV resistance a more important trait than virulence? Could you modify the environment somehow (i.e. conservation biological control) to favor the prevalence of the less UV resistant but highly virulent genotype?

– –

[To answer question A) the students apply what they learned in at least three of previous course days in addition to what they learned in this exercise]

7

Forberedelsesquiz - som redskab til forbedring af læringsmiljø ved laboratorieøvelser

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Introduktion

Laboratorieøvelser indgår som en væsentlig del af undervisningen i mange af de kurser, der indgår i bachelor og kandidatuddannelserne på det naturvidenskabelige fakultet. Formålet med de praktiske øvelser er, udover at give de studerende laboratoriemæssige færdigheder, at anskueliggøre og understøtte de teoretiske problemstillinger. Således tjener laboratorieøvelser endvidere til at imødekomme de studerendes forskellige læringsstile og strategier. På bacheloruddannelserne er de såkaldte kogebogsøvelser, hvor der følges fastlagte procedurer, den mest udbredte type af laboratorieøvelser. Denne type øvelser kritiseres dog for kun i ringe grad at give de studerende muglighed for selv at arbejde med koblingen mellem praktiske erfaringer og den bagvedliggende teori, men snare anspore til en "hands on – mind off"- praksis (Rienecker, von Müllen & P.S. Jørgensen 2013). Med denne tilgang kan det være en udfordring at motivere de studerende til at forberede sig forud for øvelsens start, hvilket selvsagt kan føre til kaotiske undervisningsforløb, som for de studerende vil opleves som tidspressede og frustrerende forløb, mens underviserens rolle bliver reduceret til formidler af lav-praktisk instruktion.

Bachelorkurset "Råvarekvalitet" (100 studerende) indgår som et obligatorisk kursus på uddannelsen i Fødevarevidenskab. Kursets praktiske del består af 4 øvelser tematiseret i hovedgrupper af råvarer "Mælk", "vegetabilier", "cerealier" og "kød". Øvelserne gennemføres i hold på 4-5 studerende og har en varighed på max 4 timer. Øvelsesgangene er tilrettelagt over seks eftermiddage, hvor 4 hold udfører øvelsen samtidigt, dvs. 16-20 studerende i laboratoriet per øvelsesgang. For hver øvelse udarbejder holdene en rapport, som skal godkendes før de studerende kan indstilles til eksamen. Som ansvarlig for øvelsen "Kvalitetsparametre for fersk kød" har jeg i tidligere år oplevet, at de studerende sjældent havde forberedt sig forud for øvelsen. Ligesom det af deres rapporter fremgik, at de havde svært ved at koble deres praktiske observationer med det teoretiske grundlag. Det er mit indtryk, at den manglende eller utilstrækkelige forberedelse medfører, at de studerende ikke har en forventning om udfaldet af deres analyser, hvilket gør det vanskeligt for dem at validere deres observationer og resultater ved at koble dem til teori undervejs. Samtidig tager den praktiske udførelse ofte længere tid, når de studerende ikke på forhånd har dannet sig et tidsmæssigt overblik over øvelsens delelementer. Samlet set flytter utilstrækkelig forberedelse fokus fra læring til afvikling og resulterer i et ufrugtbart læringsmiljø.

Formålet med dette projekt var at undersøge, om en online forberedelsesquiz vil bidrage til at kvalificere de studerendes forberedelse, således at læringsmiljøet omkring laboratorieøvelsen vil blive mindre hektisk og der for underviserens vedkommende vil blive tid og rum til formidling af kobling mellem teori og praksis. Et forbedret læringsmiljø vil betyde rum til en styrket samspilsposition mellem underviser og studerende, der forventes at øge læringsudbyttet blandt de studerende (Dolin 2013).

Metode

For at øge kvaliteten af de studerendes forberedelse forud for laboratorieøvelsen, designede jeg en forberedelsesquiz bestående af 10 spørgsmål (Appendix A) vedrørende den praktiske udførsel af øvelsen. Forberedelsesquizzen blev oprettet i Absalon, som er Københavns Universitets læringsplatform på nettet, med funktionen "Test". Formålet med quizzen var at give de studerende et redskab til at vurdere, om de under gennemlæsningen af øvelsesprotokollen havde tilegnet sig de væsentligste praktiske detaljer beskrevet i øvelsesvejledningen. Erfaringsmæssigt består forberedelsen oftest i at skimme øvelsesrapporten, fremfor mere aktivt at forsøge at visualisere eller forstå som principperne i fremgangsmåden. Tanken var, at en quiz ville motivere de studerende til at være mere opmærksomme under læsningen.

Jeg valgte at fokusere overvejende på de praktiske detaljer vedrørende selve udførslen af øvelsen og kun i mindre grad at stille spørgsmål til de teoretiske principper. Årsagen til dette valg skyldes, at jeg prioriterede, at det skulle være tidsmæssigt overkommeligt for de studerende at inkludere testen i deres forberedelse. Altså en hjælp til det de studerende i forvejen ville anse som realistisk forberedelse. Selv om jeg som underviser ideelt kunne tænke mig, at de studerende havde læst op på stoffet forud for øvelsen, ved jeg at dette sjældent er tilfældet. Langt de fleste læser først op på teorien, når de "bliver tvunget til det" i forbindelse med den efterfølgende rapportskrivning. En test som involverede kendskab til den teoretiske del af pensum ville derfor indikere urealistiske forventninger til de studerende. Samtidigt forventede jeg, at et øget forudgående kendskab til det praktiske forløb ville frigøre undervisertid i løbet af øvelsen til at sætte fokus på koblingen mellem teori og praksis og på den måde øge de studerendes læringsudbytte, hvilket forventeligt ville afspejles i laboratorierapporterne. Testen blev gjort tilgængelig på Absalon 3 dage før første øvelsesgang. På fagets "opslagstavle" på Absalon informerede jeg de studerende om, at jeg forventede de udførte testen forud for øvelsen. Jeg overvejede løbende, om jeg ville anvende "reminder"-funktionen til yderligere at opfordre de studerende, som endnu ikke havde taget testen aftenen før øvelsesgangen til at svare på spørgsmålene. Det endte dog med, at jeg ikke benyttede funktionen. Dels fordi svarprocenten helt uden yderligere opfordring var højere (> 50%) end forventet og dels fordi jeg var interesseret i, hvor lille en indsats der fra underviserens side skulle til for at forbedre de studerendes forberedelse. Det er mit indtryk, at mange undervisere gerne vil undgå "at lege pædagog" ved at sørge for at de studerende får "lavet lektier".

I den indlagte kaffepause i forbindelse med øvelsen spurgte jeg de studerende indtil, hvordan de havde oplevet brugen af quizzen i forbindelse med forberedelsen. En uformel form for gruppeinterview, hvor alle de ca. 16 studerende deltog for hver af de seks øvelsesgange.

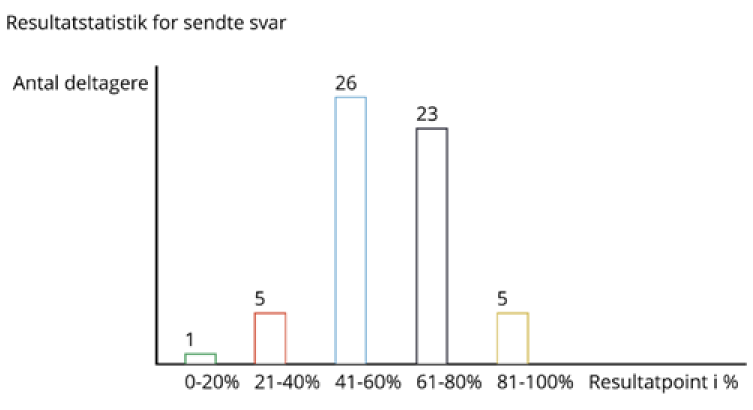
Resultater

Svarstatistikken fra forberedelsesquizzen kan ses af Tabel 7.1 og Figur 7.1. Statistikken er trukket direkte fra Absalon efter at alle 108 studerende havde været igennem øvelsen. Resultatstatistikken blev også overvåget løbende for at observere eventuelle udsving mellem øvelsesgange. Generelt var det, som det fremgår af Tabel 1, cirka halvdelen af de studerende per øvelsesgang, som havde svaret på testen. Svarene fordelte sig på tværs af hold, således at der altid var et par stykker per hold, som havde svaret. Der var altså ingen hold, hvor slet ingen havde svaret.

Tabel 7.1. Svarstatistik for forberedelsestest oprettet i Absalon som redskab til studerendes forberedelse til laboratorieøvelse på kurset "Råvarekvalitet". Testen bestod af 10 spørgsmål, hvert korrekt svar gav 1 point.

Antal studerende	Antal svar	Svar%	Gennemsnitsværdi
108	60	55,6%	6,35

For hver af testens 10 spørgsmål gav et rigtigt svar 1 point, det vil sige at det maksimale antal point var 10. Svarprocenten på 55,6% var noget højere end jeg havde forventet, idet konceptet var nyt for de studerende og jeg havde gjort meget lidt for at introducere det. Ideelt ville jeg have præsenteret konceptet i forbindelse med en kollegas forelæsning på kurset for at motivere de studerende til at tage konceptet til sig. I praksis blev det dog kun til et opslag på Absalon.



Figur 7.1. Resultatstatistik for forberedelsestest oprettet i Absalon som redskab til studerendes forberedelse til laboratorieøvelse på kurset "Råvarekvalitet". Testen bestod af 10 spørgsmål, hvert korrekt svar gav 1 point. 60 ud af 108 studerende besvarede testen.

Gennemsnitsværdien på 6.35 var lavere end jeg havde forventet, da jeg havde bestræbt mig på at lægge svarene meget tæt op af, hvad der kunne trækkes direkte ud af øvelsesvejledningen. Jeg var noget foruroliget, da jeg mødte op til første øvelsesgang vidende at blandt den halvdel, som havde udført testen, havde omkring halvdelen kun 5 rigtige besvarelser i forhold til, hvordan øvelsen skulle udføres. Selvom de studerende havde adgang til de rigtige besvarelser efter endt test, frygtede jeg, at de i stedet ville adaptere deres første antagelse og at jeg dermed med mine "forkerte" svarmuligheder ledte dem på vildspor. Det viste sig dog ikke at være tilfældet.

Gennem mine "gruppeinterview" har jeg udelukkende fået positive tilbagemeldinger på konceptet. Blandt de som ikke havde udført testen, var den mest udbredte forklaring det diffuse begreb "J*eg havde ikke tid...*". På trods af, at de ikke havde prioriteret at inkludere testen i deres forberedelse, var de positive overfor ideen og tilkendegav at de ville overveje det en anden gang, da de kunne høre på deres studiekammerater, at det ikke havde taget lang tid at svare. Blandt de som havde taget testen var tilbagemeldingen, at testen havde hjulpet dem til at fastholde fokus på de praktiske elemeter under forberedelsen og ikke bare skimme teksten, "*man tænker lige lidt mere undervejs, når man ved, at man kan tjekke sig selv bagefter.*" Der var flere som bemærkede, at testen blev opfattet mere som en service fra underviserens side og ikke som et ønske om kontrol: "*det er sjovt med noget nyt*" og "*jeg ville ønske at der var flere (undervisere) som ville lave sådan en test, for det egentlig meget rart, når man sidder der og læser og glemmer igen med det samme.*" Jeg spurgte ind til, om de ville foretrække at teoretiske begreber indgik i teksten i højere grad. Nogle få synes at det kunne være "*meget fint*", men der var bred enighed om at det ville blive for omfattende. Enkelte havde prøvet dette i andre fag, men det havde været meget tidskrævende "*som at skrive rapporten på forhånd*".

Det mindre hektiske forløb ved øvelserne blev også bemærket, "*det er rart, at vi ikke har så travlt, vi kan både nå at tænke og holde kaffepause. På andre kurser kan man knap nå ud at få en tår vand og man er helt flad bagefter*".

For mig som underviser var det mest interessante resultat dog stigningen i læringsudbytte udtrykt gennem antallet af rapporter, som kunne godkendes uden at skulle genafleveres. Jeg har rettet rapporter på kurset igennem 4 år og de foregående år har halvdelen af rapporterne skulle genafleveres før jeg har kunnet acceptere dem som godkendte. I år godkendte jeg 23 ud af 24 rapporter i første omgang.

Diskussion

Jeg meget overrasket over, hvor stor effekt et relativt simpelt forberedelsesredskab som en test/quiz havde på undervisningsforløbet. Især var det over min forventning, at læringsmiljøet havde en så markant indflydelse på læringsudbyttet, at det faktisk blev afspejlet i antallet af godkendte rapporter. Jeg havde forventet, at effekten ville være en mere diffus fornemmelse af "at det nok var mindre hektisk og mere tilfredsstillende som underviser." Det er indlysende, at den markante fremgang i kvaliteten i øvelsesrapporterne ikke alene og direkte kan afledes af, at halvdelen af de studerende har svaret på 10 spørgsmål af praktisk karakter. Men det var tydeligt, at de studerende som samlet flok havde forbedret deres forberedelse, således at mindre tid gik med at instruere i procedurer og der blev mere rum til, at jeg, som underviser, kunne igangsætte og deltage i diskussioner omkring sammenhængen mellem teori og praksis, således at deres observationer kunne kædes sammen med begreber allerede i laboratoriet og ikke først ved skrivebordet. Ifølge Illeris (2003) vil dette kunne bekrives som, at de studerendes tilegnelsesproces er blevet styrket gennem en øget samspilsproces mellem underviser og studerende.

Jeg havde valgt kun at inkludere et par få teoretiske spørgsmål i testen og hovedsageligt fokusere på den praktiske afvikling for at gøre det mere overkommeligt for de studerende at tage testen til sig som en del af forberedelsen. De studerendes kommentarer fra mine "gruppeinterview" bekræfter mig i, at en test skal tilpasses det tidsforbrug, de studerende normalt forventes at bruge på forberedelse. Hvis normen (ikke idealet...) er, at de studerende skimmer øvelsesvejledningen, vil det være urealistisk at forvente, at de bruger timer på at læse op, alene fordi der er en frivillig test tilgængelig.

Perspektiv

Generelt viser projektet, at man med en meget lille indsats som underviser, kan forbedre de studerendes læringsmiljø ved laboratorieøvelser ved at kvalificere forberedelsen med en forberedelsestest. Hvis man samtidigt ønsker en effekt på læringsudbyttet, er det er dog væsentligt, at man har fokus på at ændre sin underviserrolle fra praktisk formidler til at motivere de studerende til at reflektere over koblingen mellem teori og praksis, mens de er i øvelseslokalet. Det tog mig mindre end en halv time at oprette forberedelsestesten i Absalon. I forhold til tidligere år har jeg brugt 10 timer mindre på at rette rapporter.

A Appendix

Liste over quiz-spørgsmål

	Rækkefølge	**Type**	**Spørgsmål**	**Point**
	1	Flere svarmuligheder	Vandbindingsevne, deløvelse 1: Ved hvilken pH-værdi forventer du vandbindingsevnen vil være lavest?	1
	2	Enten/eller	Deløvelse 1.1: Er det vigtigt at pH justeres til præcis hhv 4.0, 4.5, 5.0, 5.5, 6.0, 6.5?	1
	3	Flere svarmuligheder	Når prøverne fra deløvelse 1.1 er centrifugerede må alle supernatanter hældes i vasken?	1
	4	Flere svarmuligheder	Deløvelse 1.2 % løst bundet vand: Kødprøverne til øvelse 1.2 skæres ud så de har dimensioner som?	1
	5	Enten/eller	Når jeg udregner den procentvise vægtændring i deløvelse 1.2, behøver jeg ikke at tænke på rørets vægt?	1
	6	Flere svarmuligheder	Jeg forventer at andelen af % løst bundet vand er cirka	1
	7	Flere svarmuligheder	Kødets farve, måling med minolta farvemåler: Hvor forventer du, at den største effekt af pakkemetode kan aflæses?	1
	8	Flere svarmuligheder	Kødets farve afhænger af myoglobinform. Den dominerende form afhænger af?	1
	9	Enten/eller	Deløvelse 3, konsistens: Ved klargøring af prøver til overskring på Warner-Bratzler skal prøverne udskæres	1
	10	Enten/eller	Hvilken kødtype forventer du er mest mør?	1

Part II

Course redesign and constructive alignment

8

Redesigning the course “Research Methods in Social and Clinical Pharmacy”

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Introduction: description of the course and profile of the students

The course “Research Methods in Social and Clinical Pharmacy” is an elective course placed in Block C of the “Cand.Pharm” degree program and the Master in Pharmaceutical Sciences degree program, line III. This course is compulsory for students who will be writing their master’s thesis at the Section of Social and Clinical Pharmacy at the Department of Pharmacy and therefore is linked to the development of their thesis project. The course was created with the idea of giving the students a deep understanding of the methods most commonly use in the field of social and clinical pharmacy and that most of them will be using during their master thesis. It is therefore quite relevant in this regard, as most students have only been briefly introduced to these methods in the compulsory course “Samfundsfarmaci”.

The methods taught are divided into two blocs: qualitative methods (individual and focus groups interviews, observations and document analysis) and quantitative methods (surveys, register-based studies, epidemiology and statistics). Due to the variety of methods and a stronger tradition within the section towards qualitative methods, the qualitative methods are taught more in depth. Also, the majority of the students writing their thesis at the section tend to choose qualitative methods for the development of their master thesis.

Students choosing to write their thesis in the Social and Clinical Pharmacy section are mainly interested in pharmacy practice, hospital pharmacy, patients’ perspective in medicine use, rational use of medicines, pharmacy policy and more recently pharmacoepidemiology, pharmacovigilance and market access of pharmaceutical products. The majority of them plan to work either at a community pharmacy, the hospital or for the pharmaceutical industry when they graduate, and common for them is that they are not especially motivated to work in the laboratory with, for example the formulation or development of medicines.

The course has been offered for 5 years. It has been outsourced for a couple of years and since 2012 the organization, administration and design is again taken care of internally. In recent years, there has been an increase in the number of international students since the Master in Pharmaceutical Sciences started in 2012. Nowadays, around 25% of the students are international and 40% have a mother tongue other than Danish. In the year 2014-2015, 9 different mother tongues are spoken among the students. Although the majority of the students are pharmacists, the students come from other academic backgrounds like global health, biotechnology or chemistry.

Aim

The implementation of this assignment is part of the supervision sessions and the development of my teaching portfolio. This assignment is an attempt to redesign the course "Research methods in social and clinical pharmacy" with the intention of making it more aligned and therefore more effective regarding the development on skills and competencies of the students.

Challenges related to the learning objectives, teaching activities and dynamics of the course

The first challenge facing this course is that the master thesis supervisors expect the students to be sufficiently independent when it comes to working with the method they plan to use for their master thesis. What is happening today is that the majority of the students get an overview of a variety of methods, but do not really have a deep understanding of any of them. As it is assumed that the master thesis supervisor should not be using supervision time to "teach" and explain methods and methodological issues, it is expected that the course should cover all the methods and at the same time, go more in depth with the methods most commonly used by the students.

This is of course a great challenge taking into consideration the variety of methods and the length of the course. Just to give an example, each method is often taught in a one three-hour session, when in ideal circumstances it will take a week to work with it.

The second challenge is that it is expected that the students will work with their thesis topics throughout the course. This has proven difficult since the course begins in November, ends in January and the students begin working on their thesis in February, and not all students have a clear idea of their research topics prior to February. For example, for the current course only 1/3 of the students have a very clear idea of what they will be working with, whilst 1/3 have only a general idea and the final third are still waiting for some feedback from their supervisor or are still struggling to find the master research topic.

The third challenge has to do with the tendency towards surface learning of those methods that the students consider irrelevant for their master thesis. There is also a tendency to see this course as an "easy one" given that it is a passed/fail course. It is also my perception that, at this, the final stage of their studies, many of the students are very oriented towards finishing and finding a job.

The forth challenge has to do with the quantitative part of the course. The section has an interest in introducing the students to a variety of relevant quantitative methods. These methods are those dealing with pharmacoepidemiology - the distribution among the population of diseases provoked by the intake of medicines - and with pharmacovilance, the registration and reporting of adverse drug reaction and side effects. However, for a good understanding of these two methods, knowledge of statistics and statistical computer programs is needed.

The fifth challenge is related to a growing interest in the area of market access of pharmaceutical products. Pharmacoeconomic related methods are used in this area and students working within this this field need to know, but it has not been covered by the course so far.

The sixth challenge is that around 25% of the students are writing their thesis in the area of clinical pharmacy, which in Denmark basically deals means hospital pharmacy. However, this area, although it shares methods with social pharmacy, has specificities that need to be addressed. Skills and knowledge of these specificities among the current teacher in staff are missing in this regard.

The last challenge has to do with the diversity of the students, especially in terms of cultural background and with the merging of two learning programs: “cand.pharma” and the master in pharmaceutical sciences. It is also my perception that there is very little interaction between the international and the Danish students. Although this is not in itself a problem, I believe that more interaction among students could definitively benefit them not only in social terms but also academically, as they all could gain from sharing knowledge of the different healthcare systems and how these system deal with social and clinical pharmacy issues.

Resigning the course: revision of objectives and adjustments of teaching activities

The following section presents the adjustments either proposed or implemented as part of the teaching training program assignment and supervision sessions. Table 8.1 describes the Intended learning Outcomes (ILOs), the Teaching and Learning Activities (TLAs) and the assessment tasks (ATs) of the course this year compared to the previous one and the pedagogical models or theoretical inspirations supporting the revisions introduced. The major revision has been aimed at aligning the ILOs with the TLs, making the objectives more realistic and less ambitious while at the same time including more teaching and learning activities.

Table 8.1. Adjustment of learning objectives, learning and teaching activities and assessment tasks

Objective (before)	**Overall objective (revised 2014)**	**Pedagogical models or theoretical frameworks**
to develop the participants' methodical and practical skills in phrasing research questions in social and clinical pharmacy and designing an evidence-based study using quantitative and/or qualitative research methods.	To contribute to the development of the participants' methodical and practical skills in phrasing research questions in social & clinical pharmacy and designing an evidence-based study using quantitative and/or qualitative research methods.	Learning goals in a university curriculum should be expressed in terms of the capabilities of learners on graduation. Bowden (2004)
Course outcome	**Specific ILOs (1)**	
After completing the study unit the students are expected to have gained a thorough and practical knowledge of how to phrase research questions in social and clinical pharmacy and choose the appropriate research design. Furthermore the students will master the selection of, and the use of, both qualitative and quantitative research methods within clinical pharmacy and social pharmacy projects. Such skills will have relevance for Master's thesis and future paid employment within the field of medicine.	By the end of the course the students: 1. will have gained general knowledge of the research methods most commonly used in social and clinical pharmacy *(knowledge)* 2. will be able (2) to transform a problem into a research question in the field of social and clinical pharmacy *(skills)* 3. will be able (2) to decide when to use qualitative and quantitative methods or both *(skills)* 4. will be able (2) to critically read a scientific study in social and clinical pharmacy *(skills)* 5. will be competent in at least one (3) qualitative and one quantitative research method chosen by them. These methods should be of relevance for their master thesis and in line with their future professional preferences (4) (competence)	(1) Biggs and Tang (2007) recommend including no more than five to six course ILOs, as the alignment otherwise becomes too complicated. (2) Biggs & Tang (2007) distinguishes declarative knowledge from functioning knowledge (p. 72). Declarative knowledge is knowledge about something or how to do something, while functioning knowledge is being able to do. (3) Strategic learning as a category of efficient learning is often a combination of both surface and deep learning. Marton et al. (1984) (4) These include teaching and learning of contents that related the profession (Biggs & Tang 2007, p. 81).
TLAs	**TLAs (revised)**	
6 hours of physical presence per week (max 12). The teacher (8 different ones) can decide whether to lecture or conduct group work. The teachers are suggested to develop assignments to be submitted by the	9 hours of physical presence per week (max 12). The teachers (8 different ones) are requested to max lecture 45 min (5). And to develop group work exercises (6). The students have to compulsory submitted 5 assignments (1 common	(5) Traditional lecturing is revisited. More interaction with students is requested and less time for lecturing is proposed.(Mazur 1997) (6)Yamane (2006, cf. Biggs and Tang, 2007,p. 141), found that groups formed by friends or voluntary

Table 8.2. Adjustment of learning objectives, learning and teaching activities and assessment tasks (cont.)

students, but it is up to them. Usually 2-3 assignments were requested to be submitted.	based on literature review, 2 qualitative and 2 quantitative) and they all have to be accepted in order to take the exam. *Presentations from former master students* Visits of former master students presenting their thesis with focus on the design and the elaboration of the method section.(7) *Consultation hours (8)* As one of the coordinators of the course, I made myself available every Monday from 9-12 am so that students could have extra time for questions or more feedback. Students could either just show up or send a short email beforehand informing about the issue they would like to discuss, including issues related to their master thesis if needed.	membership tend to use more time on off task activities than students are assigned to groups randomly. (7) The TLAs for functioning knowledge involve activities that allow the students to get their own experiences. Such activities are usually associated with verbs like solving, designing, managing, planning, performing etc. (Biggs & Tang 2007, p. 72). (8) The student should have the opportunity to enter into dialogue about the feedback and how to interpret it (Yorke 2003). Moreover Gibbs & Simpson (2002) argue that the most powerful influence on student achievement is feedback.
Formative assessment	**Formative assessment (revised)**	
Feed-back only to those who had to resubmit an assignment because of low quality. Plenary feedback sometimes provided in the classroom.	It is expected that working with different assignment and that having the possibility to work with their master thesis topic will motivate some of the students to move from a surface way of learning towards deeper learning (9). Moreover, the teacher in charge is requested to provide feedback to all the students. The feedback shall be provided for all 5 different assignments (11). Oral individual feedback is encouraged.	(9) Formative feedback and assessment takes place during teaching and learning and serves to improve both learning and teaching. Basically, the effectiveness of the teaching directly depends on the its ability to provide formative feedback (Biggs & Tang 2007, p. 163). (10) Harlem and James (1997) have the assumption that an important aim of education is to bring about learning with understanding. (11) The assessment tasks (ATs) should assess the students on their level of performance with respect to the ILOs and using the competences obtained in the TLAs (Biggs & Tang 2007).
Summative assessment	**Summative assessment (revised)**	
Written and oral exams based on case studies. All students have to answer one qualitative and one quantitative case study and present a five page report for each case. They have to present their cases orally. Furthermore, they have to be an opponent for another student and formulate three questions per case.	Written and oral exams based on case studies OR students' master thesis topic. All students have to answer one qualitative and one quantitative case study (one can be replaced by their master thesis topic) and present a five page report for each case. The have to present their cases orally. Furthermore, they have to be an opponent for another student.	

Adjustment of TLAs

The content of the course was only slightly revised. The revision was made after consulting the students' needs and preferences related to their master topic and previous experience working with research methods. Out of 28 students, only 4 did not provide feedback on this matter. Based on this feedback, specific research methods like participatory action research or realist review (methods taught the previous year) were not included.

Table 8.3. Revision of learning and teaching activities per themes

Course themes	*TLAs 2013*	*TLAs revised 2014*
Introduction to research methods	Lecture	Lecture Group work
Theory based research	Lecture	Lecture Group work
Transforming a problem into a research question	*none*	Group work
Systematic reviews	*none*	Lecture Assignment 1 2 ISU students presentations
Document analysis	Lecture	Lecture Group work
Interviews	Lecture Assignment 1	Lecture Assignment 2 Former master student presentation
Observations	Lecture Assignment 2	Lecture
Data analysis	Lecture Assignment 3	Lecture Assignment 3
Verifying the quality of qualitative data	Lecture	Lecture Group work
Introduction to epidemiology	Lecture	Lecture
Basic epidemiological estimates	Lecture Review questions	Lecture Review questions Group work
Observational study designs	Lecture Review questions	Lecture Review questions Group work Assignment 4 Former master student presentation
Introduction to pharmacoepidemiology	Lecture	Lecture
Introduction to bias, confounding and interaction in pharmacoepidemiology	Lecture	Lecture Group work Assignment 4
Questionnaires: design and analysis	*none*	Lecture Group work Assignment 5 Former master student presentation
Working with real life data	Lecture Group work	Lecture Group work
Clinical pharmacy – the model of improvement	Lecture Group work	Lecture Group work

Discussion: primary considerations regarding the main changes included.

According to the experiences of Biggs & Tang (2007) good and effective teaching may be achieved if courses are designed according to two principles (p. 50):

1. A constructivist learning theory and 2. Alignment between ILOs, the teaching/learning activities (TLAs) and the assessment tasks (ATs)

The constructivist theory explains that learners should use their own activity to construct their knowledge or other learning outcomes (what the student does is more important for the learning than what the teacher does).

With the inclusion of more specific ILOs phrased so that they are more oriented towards the achievement of knowledge, skills and terms and of more TLAs, I have tried to make the course in Research in Social and Clinical Pharmacy more effective for the students. Below, my consideration regarding the main challenges and main changes included

1. Focus on their master thesis topics

Although this course is conceived as a hands-on course where students, using their master topics learn to develop skills and become competent with different research methods, it turned out that many of the students still didn't have a clear idea of their thesis topics when the course started. This produced a sort of imbalance between those who know what they are writing about and those who are still waiting for inputs from their thesis supervisors. To overcome this problem, students were given the possibility throughout the course of either choosing their thesis topic or choosing a given case when working on assignments. Whether students with a clear idea about the topic of their research thesis benefited more from the course compared to those who had not yet have their topics defined their topic is unknown. A possible improvement to consider for next year is to require the different thesis supervisors to meet with the students prior to the course and discuss the master thesis topics more in detail. Another possible improvement to be introduced next year is to ask all teachers to adapt their teaching, group work and assignments using the students' master thesis topics as examples. This is in line with what Marzano (2004) who states that there is evidence that students learn more effectively when they already know something about a subject area and when concepts in that area means something to them and to their particular background or culture.

2. More group work and discussion to encourage deep learning

This year less emphasis has been given to lectures by extending the class hours and by asking the different teachers to prepare group work and discussions sessions. It is worth noting that when more teachers are involved (the course actually has 8 teachers), there is a tendency that courses get a broad more superficial coverage, at the expense of deeper understanding, and it is more likely to lead to surface learning (Biggs & Tang 2007, p. 82), while effective teaching should rather eliminate those aspects which encourage surface approaches to learning, and instead set the stage for students to more readily use deep approaches to learning (p. 31). Therefore, a reduction in the number of teachers for the coming year should be contemplated.

3. More emphasis on formative vs. summative assessment

With the introduction of more compulsory assignments based on their master thesis topics, it is expected that learning will not remain at a surface level. The oral and written feedback provided to the students had as aim to help students develop their ability to use the relevant research methods and train their skills to transform a given problem into a research question. Since the master thesis project is an individual one, all assignments were designed to be worked on individually. This allows a more effective feedback given the students' needs. A possible improvement for next year is that not only the teachers but also the students could provide peer feedback. This will possibly make the formative assessment even richer as the students will be exposed to different cases and different ways of approaching social and clinical pharmacy problems.

Conclusion and further considerations

The course "research methods in social and clinical pharmacy" faces a variety of challenges and more adjustments need to be undertaken during the following years. The fact that this is a hands-on course seems to be a source of motivation for those students who have decided to write their thesis in the field of social and clinical pharmacy, but the time available and the variety of methods is a challenge for the effectiveness of the course. With the revisions introduced this year, we have tried to make the course more aligned and more beneficial for the students, but further adjustments should be undertaken.

Acknowledgements

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9

Learning from experience – Re-design of the course “Biomedicine for veterinary students”

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Background and purpose of the project

The course “Biomedicine” was hold for the first time during the spring 2014 (2x8 weeks). It is a master course for veterinary students and compromising a full degree of biomedicine for veterinary students, equaling 26.5 ECTS. The course is very comprehensive, with not less than four course responsible and 34 different teachers involved. The course had five different themes, e.g. “cancer” and “lifestyle diseases”, and the idea was that the course should be a continuous multidisciplinary learning process. Finally, the exam should allow the students demonstrate an overview of a large area, rather than very detailed knowledge of only a minor area. However, after completion of the course and the exams, it is obvious that a number of areas could be improved, especially between the intended learning outcome and teaching and learning activities. The project is divided into two parts; part 1 is an introduction part, and part 2 analyzing the major pedagogic challenges for learning in the course in the present form, and suggests actions to develop the course to be hold in the spring 2015. The analyses will be based on my own experience as a teacher, planner and censor at the course, student-evaluations and oral interviews with students.

Part 1 – Introduction

Background for the course

The course contains a full degree master for veterinary students, to whom the course is reversed for. The master level of the veterinary study education contains five different linages, one of them being "Biomedicine". The course presented in this project is the only course for the biomedicine linage, equaling 26.5 ECTS. Until 2014 the course was divided into two modules with separate exams (grades), in addition to a separate exam (pass/fail) in laboratory animal science to acquire a license to perform animal experiments. This has been the course-form of the lineage for six years, and generally there was a major satisfaction with the course from both teachers and students, which also reflected on outstanding exam performances of majority of the students. However, due to re-organization of the veterinary student program, we were imposed to gather the course from two modules to one module with one graded exam. The laboratory animal science part of the course remained unchanged and will not be discussed in this project.

Student motivation

The teacher of veterinary students should perhaps consider them more fortune than teachers at many other student directions, since the vast majority of veterinary students seem to possess an almost inherent motivation and eagerness to learn! Although very few lectures are mandatory, at least 80% of the students do frequently or always participate in the lectures/exercise. It should be mentioned that the admitting of students to the different lineages are not only based on the student's wishes. Rather, the 25% of the students with the highest average grade after completion of their bachelor of veterinary medicine are allowed to choose freely between the five lineages, the remaining students most make a priority list of their wishes. Then, if there are more students that wish a particular lineage than course capacity can hold, students are distributed to the different linages by drawing lot. Seven years ago, when the biomedicine lineage was offered for the first time, not many students wished to be admitted to this lineage. Perhaps since it was very different from that time's conception of a veterinarian, compared to e.g. the linages of companion animal diseases. Therefore, a number of students at that time were admitted to the lineage against their will. Fortunately, the lineage (due to course construction, exams, future perspectives, ect.) became a great success among the student. This quickly rumored around the bachelor students, and this year, as far as I am orientated, all 33 students attending the course had choose this particular lineage as this first priority, despite the changes of the course structure. It is obvious that this lineage aims to provide the student with work-relevant competencies and qualification required in the broad field of biomedical research. As a PhD seems to be almost inevitable for a veterinarian to be successful in the biomedical field, the students have extensive focus on achieving high grades, and since this course compromise 26.5 ECTS points, this exam is the most important exam for the final result of the students grade point average. Conclusively, I found the students highly motivated and prepared to work hard on the course right from the first day of the course.

Table 9.1. Figures relating to the course "Biomedicine for veterinary students"

Overview of the course (spring 2014)			
Number of students	33 (course capacity 36)		
Number of teachers involved	34 (hereof 5 main course responsible, 4 associated course responsible)		
Average lecture/exercise hours per day during course*	4.75 hours (excluding one week assigned for poster-design)		
Lecture (% of teaching)	29		
Exercises (% of teaching)	71 (lab. and theoretical exercises)		
Exam results			
Passed/failed	30/3		
Avg. grade point	6,7 (7,3 if non-passed grade are subtracted)		

* Exclusive preparation

Structure of the course

The course includes modules of microbiology, genetics, experimental design (including statistics), in vivo pharmacology, histopathology as well as a range of laboratory exercise to complement theory taught in the lectures.

The exam is oral without aids. The exam compromise three parts: 1) A histopathological slide (which the students have been introduced to during the course), 2) A theoretical discussion of one of four "themes" taught during the course, 3) Discussion of a poster made during the course (the poster must be different from the poster made by the group of the student to be examined. To cover all parts of the exam three exminators and an external censor is necessary.

Curriculum

Since the course is a master course, we expect the students to be scientifically mature to take responsibility for their own professional development and specialization. Therefore, the course does not have a specified curriculum list. Instead, the students are guide by throughout and specified learning outcomes, e.g. “describe principles of housing, breeding and use of laboratory animals”, or “describe inference methods and risk analysis”.

Part 2 – The analysis

My observations during the course and exam

In this section, I have stated some of the most notable observation and the lack of constructive alignment. In the course description, 12 learning outcomes, 12 skills and 13 competences are expected of the students to acquire during the course are specified.

As described, the course were ideally planned to integrate different parts of biomedicine and not to be taught as a number of fragments areas. Some of this worked nicely, e.g. was microbiology combined in a practical exercise with genetics. One part of the course (the experimental science course), however, do represent a separate part with a separate exam. This part of the course was placed somewhat in the middle of course period, which seem to interrupt the remaining course. This could be solved by placing this part in the start of the course finishing with the exam for this part, and then run the remaining course as a continuous unit.

As can be subtracted by the stated, this course does contain a board spectrum of different areas within biomedicine, and one of the most common elements of frustration that I sensed among the students, were the fact that the students did no overview of what was expected of the to know the level of details excepted of the them to process within each area. This could meet by introducing a successive number of assessments/self-assessments during the course. Class room voting tools have been shown to improve learning, and e.g. could socrative (an online class room voting tool) be used for quick quizzes allowing the students to self-assess their insight in a particular topic, and in case the level of the quiz questions should be of the level we expect the students to be able to process at the final exam. The results of the students in the quizzes could also be used constructively for the

Table 9.2. Examples of descriptions of ILO/skills/competences from the course description.

Outcomes/skills/ competences	**Assessment**	**Teaching / Learning Activities**
Describe various animal methods for human diseases Comment: A clearly defined outcome	Only assessed at the oral exam Comment: Should also have been assessed during the course, since this is one of the main ILO of the course. Could be assessed through e.g. oral presentation of the students, through written reports or through mini-quizzes during the course	Lectures regarding different model Comment: Some of the models, we expected the students to be able to described are not covered sufficiently.
Be able to find new information/literature on topics within the area of biomedicine	A number of written reports and oral presentation by the students during the course. Based on the scientific level the students ability to find relevant literature to solve the questions was assessed. Comments: Since the course is very board and covers a large area, this kind of assessment of serve at a random sample at few confined areas.	Group work of specified assignments where the students were excepted to find relevant literature of. Comments: To my knowledge, this course is the only course at the veterinary education, in which no exact curriculum is defined. Therefore, a single lecture dedicated to how we expect the students to study during the course would be worth considering
Analyze, evaluate and present results from simple diagnostic tests	Was not assessed Comments: given the extent of the course, all areas will not be able to be covered at the oral exam. However, since this topic was taught in lecture form for two consecutive days, a small quiz (e.g. using "*socrative*" software) would allow the student to self-asses their learning outcome.	Lectures on the topic

teacher to assess his/her teaching own teaching 2, leading to a contingent teaching(Draper & Brown 2004), which relies equally on both the teacher and student as to having to adapt the teaching to the correct level (Crouch & Mazur 2001).

The course is also based on a rather large portion of group work, most often followed by the students presenting their work in plenum for the other student. It is worth to notice that group work is not mentioned at all in the ILO/competences/skills of the course. Nevertheless, a total of six groups were applied throughout the course, and commonly the six group then worked with six different topics, and the intentions where that the groups should learn from listen to the each other. However, students are not teachers!! Consequently, each group might have gain some information by doing their project/assignment, but the learning outcome from the other groups (working with different topics) of such presence seems to be very limited. One way to improve the learning outcome, is to let two groups be opponents on each other project. Then they would have to be actively and critically involved in the project of the opponent group in addition to their own project. Thus, all groups would not be expect to be present through all the groups' presentation, but only when the present themselves and when their opponent group present. However, all students should be handed out the research question of all groups. These research questions should of course be constructively aligned, clarified to the student what we expected to them to be able to describe within a particular topic. Also, groups should be applied only with an aligned purpose, not to relieve the pressure on the teachers' work burden! The teacher must take responsibility to design the project/assignment of the group work in a sense that the project/assignment would benefit more from being conducted in a group, than conducted one-by-one.

Although the average grade point for the students obtained at the exam must be considered relatively high (6.7) compared to other, comparable courses at the veterinary education, in my point of view there was a major gap between what the students expected to be assessed in, and we (examinators) expected the students to be able described (discussed further in the next section).

Evaluations of the course by the students

This section is based on the written evaluation by the students (unfortunately only 12 respondents filled out the online evaluation form), a brief in plenum discussion with the student at the end of the course (but before the exam), oral interview with four students all obtained the grade 12 at the exam and two students, which had both received the grade 02 at the exam. Finally, written interviews were conducted with additional four students randomly chosen from the list of participants.

The structure of theme was intentionally meant to be divided into five themes. However, although the students recognized the themes, there were a number of lectures and exercises that the students could not place into the described topics, adding to confusion and frustration. If we wish to keep the theme-structure of the course, it is necessary to have the theme well-defined and have all teaching activities clearly aligned to one of the themes. The extensive amount of group was criticized by the most of the students. They all found that group work is rational under practical exercises (e.g. lab exercises). However, a number of the theoretical exercises were perceived by students, as initiatives suggested by the teachers to lower their own workload, not because group work served as the most optimal method to assist learning in a given topic. What we, as teachers, seem to have failed, was to create an alignment between the group work, the exam and "real-life". That is, almost all group work finished with an oral presentation of the results obtained by the groups. This is actually a great way for the students to practice their oral skills of presenting results in a scientifically substained manner with a high degree of freedom as to do this, which is actually exactly what is assessed at the exam, and definitely a valuable tool for everyday work life situation. After all, we do not want to educate student to do great on the exam (great if they do, of course), but to provide them with the optimal fundament of which the scientifically career should be build. However, then groupwork design must be optimized to be in alignment with the exam. An example of group work could be to describe the most important animal model for lifestyle diseases (one of the main themes), and discuss pros and counts with each of them. This is one of the main areas they will be expected to be able to explain throughout if the draw "lifestyle disease" at the exam, and therefore is much more constructively alignment compared to some of the group work assignments presented this year.

About 50% of the students stated that the ILOs and exam format were not clear from the start, which gave rise to some frustration. This is partly due to the challenges described in the introduction part, but also because the students are not used to use the course description sufficiently. In fact, much energy had been put into design and wording of the course description. How to use the course description could be included the "how-to-cope-with-this course"-lecture as suggested earlier.

Finally, about 41% of the students did not think that there was consistency of the exam with objectives of the course! This number is based on written evaluation, which unfortunately only had 12 respondents. However, during the extended evaluation through the written and oral interviews preformed in this project, the real number seems to be lowered, although this might be biased by majority of students that agreed to perform an interview were student in the very upper end of the grade scale.

Suggestions new pedagogic implementations for the course in 2015

Based on the analysis performed (my own experiences and student evaluations) the following suggestion to improve the level of constructive alignment of the course:

- The course plan and the exam format will be outlined before the beginning of the course.
- A course introduction lecture will be held. The focus on the lecture will be guidelines for the student, including how to use the course description effectively, how self-studies should be performed and how to study for the exam.
- The course should be launched with "experimental animal science" including the exam for this part.
- Group work will only be applied if it can be justified to promote the learning process and the type of assignment must by in alignment with the intended learning outcomes outline for the course
- All major parts of the course should be assessed, not only during the exam, but also during the course. This would help the students to recognize possible weak points and allow the teacher to continually evaluate the outcome of his teaching activities.
- The structure of the course being divided into themes should be retained, however, all disciplines taught should be included into one of the themes.
- All topics/areas of the course are expected to be performed either though lectures, practical or theoretical exercise with at least one other area of the course (e.g. microbiology and genetics).

10

Deep approaches to learning and constructive alignment - Redesigning the course “Economic geography”

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Introducing the study

In block two 2014/2015 I was the course responsible and teacher in the course ‘Economic Geography’ for the first time. As teacher I saw it as my prime task to create a vibrant and aligned learning environment in which the students wanted to understand the details and underlying structures of theoretical and societal economic geographical structures and changes. To achieve this, the students’ preconditions, preferences and approaches to learning need to be well-adjusted to the teaching context and intended learning outcomes (Biggs & Tang 2011*a*).

In the literature a distinction is made between surface and deep approaches to learning (Ramsden 1999, Biggs & Tang 2011*a*). A surface approach is characterized by a shallow cognitive level in which learning is driven by routines and an aim of meeting the requirements (e.g. examination requirements) instead of a wish to understand the subject matter. On the other hand, a deep approach to learning is characterized by an active attempt to understand the matter of learning, the details and the underlying ideas of the teaching. Students’ approaches to learning are mediating variables dependent on their perception or experience of learning, and the learning outcome is affected by the chosen approach (Illeris 2003). Thus, students have different preferences in their approaches to learning, and according to Biggs & Tang (2011*a*) sound learning occurs when the personal preferences and preconditions of the students interact with the teaching context and intended learning outcomes (ILOs). Teaching and learning activities (TLAs) that focus on activating the students will lead to greater opportunities for engaged and reflective students which then results in deep learning and learning outcomes of high quality. More students achieve deep learning when the teaching is constructively aligned (Biggs & Tang 2011*a*). Constructive alignment is a pedagogical model with focus on the connection between ILOs, TLAs and evaluation, and how these components affect learning (Mørcke & Rump 2013). The model is based on a constructive understanding of learning implying that the learner actively constructs his own knowledge. The ILOs of the teaching must specify both the TLAs the students should engage in to meet the outcomes as well as the academic content of the TLAs. It is then the task of the teacher to create a learning environment that encourages the students to engage in the TLAs, and to evaluate the students' learning according to the ILOs. Constructive alignment is achieved when ILOs, TLAs and evaluation are aligned (Biggs & Tang 2011*a*).

At the given time, I was not allowed to rephrase the ILOs or the examination format for the course, and therefore I had to account for the existing study programme when planning my teaching. Following the theoretical arguments outlined above, this study investigates if and how it is possible to stimulate deep learning and achieve constructive alignment in a course with pre-given ILOs. Explicitly, the study explores how students from the course 'Economic Geography' evaluate the different TLAs used in the teaching and whether or not these lead to deep learning approaches and a feeling of constructive alignment.

In the following pages, I first present some general information about the course 'Economic Geography'. Second, I describe the TLAs I have used in the course and how these are intended to the pre-given ILOs and examination format. Then I present some of the results I gained from doing a focus group interview with six students from the course, followed by a discussion of these results and my own experience. Lastly, I conclude the study with some reflections on my future teaching tasks.

The course 'Economic Geography'

The course 'Economic Geography' is an elective course at the third year of the Bachelor's programme in Geography and Geoinformatics at University of Copenhagen (see appendix A for ILOs). The format of the teaching is student-activating classroom teaching two times three lessons per week, equalling 7.5 ETCS. The exam form is written, namely a 30 hours individual essay.

In block two 2014/2015 I was the course responsible and sole teacher at the course. I planned the curriculum in cooperation with the former course responsible, while I have planned the actual teaching and learning activities on my own. 14 students followed the course.

Teaching the course 'Economic Geography' - the use of teaching and learning activities

It was the first time as course manager for the given course; therefore I had many considerations on how the course was related to the overall Bachelor's programme in Geography and Geoinformatics. Specifically, I thought about which academic level of knowledge on economic geography I could expect from the students. I the study programme it is phrased that an academic level corresponding to the compulsory courses at the Bachelor's programme in Geography and Geoinformatics is recommended. However, experience from former colleagues showed that students with other academic backgrounds often followed this type of course. Therefore, I was aware that I could not expect all students to know about geography specific theories or concepts. Consequently, in the first lesson I used a lot of time to get knowledge of the students' academic preconditions and throughout the course I made sure to ask if anything needed more explanation. Moreover, and as an effort to attain constructive alignment, I always repeated central concepts and theories, and put them in to perspective in relation to the geography education and the ILOs for the specific class as well as for the course in general. This is in line with Johannsen et al. (2013) who argue that a clear statement of the objectives of the topics presented in teaching are crucial for the students to engage in the teaching.

Understanding and arguing for different economic geographical approaches, theories, concepts and methods was highly weighted in the teaching as in the overall ILOs for the course. The TLAs I designed for the course was therefore based on dialogue and activity. Namely, in the beginning of every class I gave short dialogue-based lectures including small breaks for reflection and discussion with the neighbor student; every second class a group of 2-3 students gave (guided) presentations on specific topics or articles. Two times during the course I gave the students an opportunity to do individual written assignments which reflected the formulation of the essay question of the exam to practice their writing skills. The writing was done in the students' spare time and it was optional to do them. The essays were given peer-feedback from fellow students in class and common feedback in plenum from me. Furthermore, in every class I planned some kind of group work - the students spilt up in small groups and discussed parts of articles, figures or arguments sometimes to be followed by discussions in plenum while other times the small groups was then divided into other groups - matrix-groups - and then they explained/articulated the subject discussed in the first groups.

The format for the exam was a 30-hours essay based on a pre-given subject. Therefore, the TLAs I planned for the teaching were designed to make the students construct their own knowledge about economic geography through articulation and argumentation – both through student presentations, group work and in the written assignments. My intention was that these different TLAs would stimulate the interest for economic geography among the students leading to deep learning approaches, and assure constructive alignment between the ILOs, TLAs and evaluation of the course.

Findings and analysis

To evaluate whether the students felt that the course was constructively aligned, and if the chosen TLAs – or some of them - stimulated deep learning approaches, I invited the students to a focus group interview two weeks after the exam. Six of them agreed to be interviewed. The interview lasted two hours and took place in a teaching room at the geography section at IGN. In the interview I asked the students to discuss the different forms of TLAs that were used in the course and how these resulted in their approaches to learning. Moreover, I explained the theory of constructive alignment and asked them to discuss if they felt that the ILOs, TLAs and exam format were aligned, and if there were any specific initiatives they could point out as decisive.

We started by discussing the dialogue-based lectures given by me. The six students all agreed that starting each class with these short lectures was helpful as they set the scene for the topic of the day. One student said: "Almost every time we sat there, and you gave the lecture, I experienced a kind of an epiphany", while another one said that: "It was a quite an intense course, and therefore the lessons were necessary, especially when you repeated the core themes from last time and told us how they related to the next texts we had read, as they helped me understand them better and relate to the topic of the day”. However, it was also stressed that the lectures were great because that were structured around the ILOs of the day, and because they were held short.

Secondly, we discussed the student presentations. The meanings about this TLA were more diverse. Some of the students really liked doing presentations because they felt that they learned much from articulating the arguments and explaining the core concepts to fellow students. While others didn’t like it that much, as one student explained: “...to me it was much more about the responsibility – actually I felt like I was presenting for the teacher instead of the class – like an exam. I don’t like being the center of attention”. Regarding other students’ presentations the meanings were also diverse; some felt that it was a waste of time, since many of the fellow students were bad at communicating the central points of the texts, while others felt that getting core concept explained by peers made them more understandable. The conclusion was that the profit depended much on the presenters’ ability to present (“not talking inwards”) and prioritize and articulate important arguments.

All the interviewed students agreed that working in small groups discussing parts of a text, figures or arguments was fruitful, as explained by one of the interviewees: “Group work is nice. Discussing an academic argument with peer students made me feel more assure that I understood it correctly, and I was therefore more comfortable articulating my ideas in front of the whole class afterwards”, and another one followed up saying that: “...when being divided into small groups I felt responsible to add my comments to the discussion, while in discussions with the entire class it was easier to ‘hide’ and remain silent”. Also TLAs in which the groups had to produce things, like drawing time lines of the field etc. were highly liked. However, group work with matrix group discussions was a clear favourite among the interviewees: “I was a huge fan of matrix-groups. It was the first time, I experienced matrix-education, and I love it. It was really really great to feel that you have discussed sometime throughout and then being responsible for teaching your peer students and they doing the same for you”. Another student agreed and uttered that the reason why the matrix-TLA was better for him than doing plenum presentations after group discussion was “...the informality in matrix groups (...) Sitting in a small group and being responsible for teaching the other students focus is on your oral argumentations and not on stating the right argumentations on a power point, it is just a different approach, but to me it felt so much better and I learned so much more from that". On the other hand, another student said that he was not that big a fan of the matrix-TLAs because then he only heard the argument from one peer student, and then he couldn't be sure that it was right "I was more comfortable when doing plenum discussions because then I could always be sure that you would be there to moderate the answers and arguments".

Three of the six interviewees did both of the written (optional) essay assignments, while one interviewee did only write the first one, and two didn't do any. The ones whom did both of the essays uttered that they learned from doing it, as one of them said: "In class we learned how to express our arguments orally, but by doing the essays assignments I also learned to express myself in written form, and that was a great motivation to me. Also because when doing an essay I had to be very clear in my argumentation since the reader was not there to respond immediately as in an oral discussion". The one interviewee who did only one of the essays saw it more as a direct preparation for the exam: "First of all, it was great because I then understood the format of an essay exam. Secondly, it saw it as a way of understanding your ideas of what was important in the exam situation". However, they all agreed that peer feedback followed by common feedback from me was not enough: "It is always nice to hear others' opinions on your work. However, it is not my fellow students who will mark my exam essay – It is you, therefore I would have liked to have more personal feedback from you", and another interviewee uttered that "the fellow feedback was much more about spelling and articulation mistakes instead of feedback on structure and understanding, thus I felt that the peer feedback was more or less useless". One of the students who chose not to do the written assignments argued that there was not enough time to do them between homework (also from another course) and uttered a wish of replacing some of the curriculum with the assignments, while the other one wanted them to be mandatory because: "When I prioritize my time, I always do the required stuff first and honestly, I'd rather watch a movie than write an essay. However, in hindsight, I wish I would have made them, so to me it would have been great if they had been compulsory. Maybe if you have integrated the essays into the course a little more I would have felt that it would have been necessary to make them and that would have been a motivating factor for me".

Finally, I asked the interviewees if the felt that the course was constructively aligned and if they could point to specific initiatives that helped this. First of all, they said that they felt that there was great alignment between the course description in the study programme and the content of course. The interviewees all found some kind of alignment in the course; however, their opinions on what made the alignment were diverse. One student uttered that the fact that I started every class with starting the ILOs of the day, relating them to the texts and the TLAs was a big help to him: "...it really made the purpose of the class, and the entire course, very clear to me. And when I was doing the exam essay I realized how helpful this has been because it was so much easier for me to remember which parts of the curriculum were important in my different arguments – I have actually never felt so prepared for an exam as I did for this one." Another student, however, felt that stating the ILOs in the beginning of a class and then returning to them in the end seemed "a little clichéd"; however during the exam "...it became clear to me why you did it". Yet another student felt that it was needless as he forgot about them during class. Another student agreed and said that in the beginning of the course, it actually scared him "I have never experienced a teacher stating the ILOs before, and then when I forgot them during class it was like 'Oh no, I forgot the purpose of what I'm doing'... But then I got used to it, and realized that they were not that important".

Many of the interviewed students felt that they that the fact that I used the last class to elaborate on how the course fit into the entire study programme was useful for them, while an interviewee, who followed the course as part of another education than geography, had – obviously - difficulties in seeing this course as constructively aligned with the rest of his study programme. However, he uttered that he found the course quite interesting and wanted to make use of his knowledge on economic geography in the remaining time of his education. Some of the interviewees argued that the different types of TLAs seemed well-chosen and that fact that it was stated on a power point why the specific TLA would guide them to understand a specific concept or theory and why, was what helped them in seeing the course as aligned. And the fact that the TLAs involved student activity and discussion "helped me see – and construct – the bigger picture".

As a final point, we discussed the exam and its alignment with the course. Most of the interviewees were unhappy with the format. They felt that 30 hours for writing an essay were too short not leaving enough time for reflection. However, while some of the students argued that an oral exam would have been fairer as it would have reflected the teaching better, others felt that the written form was fine because of the written assignments during the course: "then I knew how to do it".

Conclusion - learnings and perspectives for future teaching

Based on my own experiences and the focus group interview with six students, I conclude that the ambition of stimulating deep approaches to learning in the course in Economic Geography was reached. Introducing different TLAs focused on activating the students stimulated their engagement and interest in the field. However, as argued by Biggs & Tang (2011*a*) students' preferences in learning approaches differ which were also shown by the discussion of different TLAs in the focus group interview with the students; some students were happy about presenting in front of the class as it helped them clarify their argumentations while others liked the matrix group TLAs more. Moreover, in a course like this with a mix of academic preconditions amongst the students, this may also influence a variety in approaches to learning. Thus, my conclusion is that it is important to introduce a variety of TLAs during a course – or even in a single lecture – if you wish to engage as many students as possible.

The interview showed that even though I had to stick with the pre-given course description and ILOs, the students felt that there was alignment between the course description, the content of the course, and the different TLAs. This was one of big greatest concerns when taking over the course because I changed the curriculum while leaving the course description unchanged. In my attempt to attain constructive alignment I realized that I had to break down every class into little pieces and think about the ILO of every text, activity, and discussion and then formulate overall ILOs for every specific class and relate them to the overall ILOs of the course. It took a lot of effort, and even if I've taught many classes before I have never been so detailed and structured about my teaching before. However, as the interview showed the hard work was fruitful especially articulating the ILOs for the day in every class, and I will use this approach for my future teaching both in courses where I am allowed to change the course description and in courses where the framework is pre-given.

In the meantime, constructive alignment is achieved when ILOs, TLAs and evaluation are aligned (Biggs & Tang 2011*a*, Mørcke & Rump 2013), and as the interview showed, many of the students did not see a written exam as aligned with the rest of the teaching and learning styles in the course. I was much aware of this before I started teaching the course because the ILOS and the format of the course (2·3 hours weekly seminars) emphasized oral discussions. I therefore introduced the written assignments as an attempt to get constructive alignment. However, not all students saw these as satisfying. A solution to this could be to make the assignments mandatory and integrate them better in class including using more time on feedback. In the future when I have to teach courses with a pre-given framework and exam format I believe this will be a good solution, and if I'll be allowed to change the course description on this course, I would change the exam format to a final oral exam possibly with ongoing evaluation in form of small written synopses on the central themes of the course as I believe that would make the course better constructively aligned.

A Intended learning objectives of the course 'Economic Geography' stated in the course catalogue

Knowledge: Localisation theories, economic competitiveness, the spatial organization of production, innovation, labour, technological development, urban and regional development, regulation, socioeconomic networks, global economic flows.

Skills: Students can expect a throughout theoretical explanation of the following topics:

- General patterns and interdependencies in global economic flows, and the relationship between economies and politics including the significance of regulation

- Central theories on urban and regional development

- The significance of labour for the spatial concentration of economic activities and to combine this with knowledge on regulation of local labour markets

- Differences and similarities in the economic integration of Asia, Europe and North America, and the increased post-war tendency for regionalization including the economic and political role of the nation state.

Competences: To apply methodologies, analyse and evaluate results and data in relation to the spatial organisation of production and regulation of global and local economic conditions.

11

Assessment tasks in the course ‘Energy Systems and Climate Change Mitigation’: ensuring constructive alignment

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Introduction

In this project, where I focus on exams and assessment tasks in the course ‘Energy systems and climate change mitigation’ I wish to, based on the theories on constructive alignment, particularly the learning outcome-assessment task dimension (ILO-AT), explore how student case work as a teaching and learning activity (TLA) can be integrated in the final assessment/exam to further increase course alignment.

Constructive Alignment (CA) is an outcome based didactic theory developed by John Biggs. The fundamental assumption is that deep learning is supported by focusing on what students do rather than on what students are, or what teachers do (Biggs & Tang 2007, Mørcke & Rump 2013). CA builds on constructivism (hence the first part of the name) as formalized by Jean Piaget (Dolin 2013) suggesting that learners construct new knowledge out of their present experience through an interaction between that experience and the experience of the surrounding world, e.g. a teacher.

‘Alignment’ refers to the process of stimulating deep learning by ensuring that the learner experiences coherence between what the learner is expected to become capable of (Intended Learning Outcomes, ILOs), the learning environment (Teaching and Learning Activities, TLAs) and the assessment of the learners learning (Assessment Tasks, ATs).

With respect to assessments Biggs & Tang (2007) argue that while teachers often consider the ILOs as the guiding element in a teaching-learning event students might consider differently. To the student passing the exam is the element that guides learning activities (Fig. 11.1). This so-called (negative) backwash effect leads to surface learning.

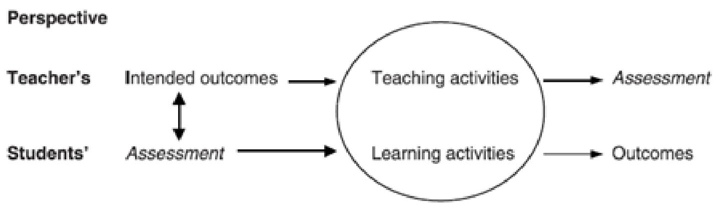

Fig. 11.1. Teacher's and student's conflicting view on assessments. Adopted from Biggs & Tang (2007), fig. 9.2, page 169.

Backwash can be used positively. If the final summative assessment is aligned with the learning outcomes then teaching activities and learning activities focus on the same goal, the ILOs. When students prepare for the assessment they automatically train for the learning outcomes (Biggs & Tang 2007, Frankland 2007).

Material and methods

This report is based on own experience teaching the course in 2014 and 15, and on oral feedback from the students. Written evaluations on Absalon were few and did not provide specific input to the question treated here. It hasn't been possible to carry out the suggested changes of exam forms within the timeframe of the Teaching and Learning in Higher Education programme.

Course

The course 'Energy Systems and Climate Change Mitigation' is a 7.5 ECTS restricted elective course in the MSc programme in Climate Change at University of Copenhagen. The course covers one block (8 weeks) in the spring semester. Apart from climate change students the course is open to students from other programmes at UCHP and from external students. The course was executed first time in 2014 (academic year 13/14) with 30 students.

In 2015 40 students attended. The final assessment and grading of students is based on four hours written test at the end of the course. The test takes place at the university (corresponds to exam type IV in table 11.2). The test is a mix of calculation exercises, discussion items and multiple choice questions. Multiple choice questions are used to test basic facts like energy conversion efficiency, energy units and forms, and scale relations (ILO 2). Discussion items focus on evaluation of strategies and interrelations between energy and climate systems (ILO 1 and 4). Calculation exercises target ILO 1, 2, 4 and to limited extent 3.

Course alignment

Course alignment The level of course alignment is presented in table 11.1 below. By comparing the lecture plan, learning outcomes in the course description and the options provided by the exam form I find misalignment between some assessment tasks and learning outcomes. As can be seen from table 11.1 misalignment particularly occurs for the elements emphasizing the highest level of understanding (level 4 and 5 in the SOLO taxonomy).

I evaluate the current exam form inadequate of supporting ILO 3, 5 and 6 because these requires more time that four hours for the students to identify relevant problems, find and analyse data, and reflect over strengths and weaknesses of potential solutions. Moreover ILO 6, work in interdisciplinary groups, is incompatible with the current exam form.

Student feedback and own experience

A core element in the teacher’s and course responsible’s approach to teaching the course is to provide the students with hand-on experience in developing, designing and evaluating renewable energy systems at all scales (ILO 4-6, table 11.1). A chosen activity to support that outcome is group work on a self-elected case. From my perspective the case work is very valuable in supporting the learning outcomes and this is seconded by student feedback.

Suggested changes

In the following I present my suggestions for changed exam forms to ensure further course alignment in support of deeper learning. However exam

Table 11.1. Evaluated levels of constructive alignment between intended learning outcomes (ILO), teaching and learning activities (TLA) and assessment tasks (TA). Central verbs in the ILOs are set in italics. The 'SOLO' column refers to levels of understanding following the SOLO taxonomy (Biggs & Tang 2007), table 5.1 page 80. Filled arrows indicate alignment, open arrows indicate misalignment.

TLA		ILO	SOLO		AT
Lectures, exercises and group work (Module 1: Introduction, module 3: non-renewable energy, module 4: renewable energy)	→	Understand and *describe* the interrelations between the climate systems and the energy systems	3	←	Final exam (individual written summative assessment)
Lectures, exercises, group work and excursion to power plant (Module 2: thermodynamics, module 4: renewable energy)	→	*Describe* the renewable energy technologies available to mitigate climate change	3	←	Final exam (individual written summative assessment)
Exercises and group work on self-elected case (Module 3: non-renewable energy, module 4: renewable energy, module 5: energy systems)	→	*Analyze* existing energy systems, at all scales, and their contributions to climate change and mitigation	4	⇦	Final exam (individual written summative assessment)
Lectures and group work on self-elected case (Module 5: Energy systems)	→	*Evaluate* the appropriateness of alternative strategies for transformation of the energy systems for climate change mitigation	4	←	Final exam (individual written summative assessment)
Group work on self-elected case (Module 5: Energy systems)	→	Contribute constructively to the *design* of sustainable energy systems at all scales	5	⇦	Final exam (individual written summative assessment)
Lectures, exercises and group work on self-elected case (Module 1: Introduction, module 2: thermodynamics, module 4: renewable energy, module 5: Energy systems)	→	Work in inter-disciplinary groups to *solve* problems related to energy systems and climate change mitigation	5	⇦	Final exam (individual written summative assessment)

forms cannot be changed at will and all forms have their benefits and weaknesses, which are discussed.

Regulatory framework

Exam forms are particularly regulated by ministerial order 670 of 19 June 2014 on exam and censorship at university studies [Bekendtgørelse om eksamen og censur ved universitetsuddannelser] (Uddannelses- og Forskningsministeriet 2014), and the joint curriculum for BSc and MSc programmes at the Faculty of Science (UCPH 2015). The ministerial order section 4 states that exams can be organized as individual or group tests but in any case an individual assessment must be performed followed by individual grading of the students.

The curriculum section 6.1 states that exams can be organized as one or more tests leading to either a weighted assessment and grading of the individual tests or an overall assessment and grading of the test portfolio. Furthermore section 6.4.1 states that written tests can be organized as individual or group tests. However, group tests must allow for individual assessment and grading of the students requiring either a declaration of the individual contributions by each student to the written work or a subsequent oral examination.

The core constraint is that no matter how the final assessment and grading is organized it must provide the examiner and censor the means to assess and grade the students individually.

Exam forms

It is important that the choice of exam form ensures reliability as well as validity (Biggs & Tang 2007, Andersen et al. 2013). Reliability meaning that the assessment and grading is unequivocal, transparent and not dependent on external factors like the student, examiner or censor them-selves, the place and surroundings but only on the performance. Validity requires that the exam tests the learners' learning with reference to the purpose of the learning (ILOs). An example of low validity is presented by Vennervald (2010) in her project on a course in human parasitology, where a multiple choice test was found inadequate to test "*the students' abilities to analyse problems in relation to human parasite infections in a broader context in relation to human health*".

Andersen et al. (2013) distinguish exam forms by product type and where the exam takes place. Exam forms commonly encountered in Denmark are illustrated in table 11.2 below. An exam form more commonly used abroad, course participation, is in a Danish context and regulatory framework considered a prerequisite for exam participation rather than an exam form in it-self (Andersen et al. 2013). Within each form the exam can be executed in numerous different ways.

Oral exams are often considered having relatively low reliability because they depend too much on e.g. chance, personality, and the student's eloquence and language proficiency (Andersen et al. 2013). On the other hand the oral exam allows the (good) examiner to test the student's conceptual understanding and not only her/his ability to reproduce facts. Higher reliability is associated with some forms of written exams, e.g. multiple choice tests, calculation exercises as assessment and grading relies on the product (result) rather than on the process of reaching the result. As such the subjectivity is removed from the assessment.

Table 11.2. Exam forms distinguished by product type and place. An off-site exam takes place where the student determines. An on-site exam takes place at the educational institution or a place the institution determines. Adopted from Andersen et al. (2013), figure 1, page 372.

Product type / Place	Written	Written + oral	Oral
Off-site	I) Written product made off-site (thesis, project report, case report, portfolio)		
Off-site + on-site	II) Written test on-site following a written product made off-site (rare type)	III) Oral test on -site based on written product made off-site (thesis, project report, case report, portfolio)	
On-site	IV) Written test on-site (exercise set, multiple choice, essay)		V) Oral test on-site (with or without aid, with or without preparation)

New form

A new exam form must emphasise alignment on the ILO-AT axis with focus on learning outcome 3, 5 and 6 without changing the well-established ILO-AT alignment for outcome 1, 2 and 4. A shared teaching activity targeting outcome 3, 5 and 6 (and 4) is the self-elected case work, and I find it obvious to include, in some form, the case work in the final assessment. The output of the case work is a poster and an oral plenum presentation of the poster. As organised currently neither the joint poster nor the plenum presentation meets the regulatory requirements for individual assessment (curriculum sections 6.4.1 and 6.4.2), and based on the positive feedback on the case work and own experience I would be hesitant to change the format.

Execution of oral exams is generally perceived as more resource demanding than written exams (Andersen et al. 2013). This may particularly be true to courses with many students. With the number and growth of students in the ‘Energy Systems and Climate Change Mitigation’ course oral exams is not considered feasible. Consequently an individual oral exam based on the case work (type III, table 11.2) is not considered.

My suggestion for a new exam form is a weighted two part exam. One part is an individual essay based on the case work weighing 40 % (type I, table 11.2) and the other part is a shorter, e.g. 2.5-3 hours, written exam comparable to the current (type IV, table 11.2) weighing 60 %.

Reflections

My suggestion for a new exam form for the ‘Energy and Climate Change Mitigation’ course could achieve the goal of course constructive alignment and ensure a reliable and valid assessment of the students learning.

The essay part of the exam allows the students to analyse, characterise, compare, contrast, generalise and reflect on their own experience and learning. All verbs associated with the relational and extended abstract level of understanding in the SOLO taxonomy (Biggs & Tang 2007). To achieve this, the essay should not be a summary of the poster and case work but a personal reflection over the implications and perspectives of the case work findings. If planned and organised well the essay could target learning outcomes 3-6. A risk with the essay format suggested here, produced un-invigilated is plagiarism (Andersen et al. 2013). However, as it will be based on supervised case work, I believe the risk is small, but for that reason I suggest it to account for less than 50 % of the final grade.

To minimise the risk of plagiarism and other fraud it is important to set up a very clear framework of guidelines and expectation for the students (Andersen et al. 2013, Biggs & Tang 2007), and finally software exist to detect internet plagiarism.

The validity of the suggested format is high as it builds on a real life case. Reliability in the assessment and grading is challenging for the examiner and censor and requires not only that they are experienced in assessing written work, but also a comprehensive documentation of the assessment (Andersen et al. 2013).

The written on-site test could be used more specifically to target learning outcome 1-4 with calculation exercises and multiple choice tests. These test forms are considered highly reliable (Andersen et al. 2013). Validity of the test must be ensured in the formulation of test items as topical, timely, and targeted conceptual understanding.

Misalignment on the ILO-AT axis is experienced in other courses and treated in earlier projects in the Teaching and Learning in Higher Education programme. Vennervald (2010) suggested a change from an on-site multiple choice test to an on-site, heavily guided, short essay based on a scientific paper to e.g. ensure alignment, encourage deeper learning, assess higher levels of the SOLO taxonomy, and activate students. When Damsgaard (2013) found ILO-AT misalignment in a course in human nutrition she did not change exam form (on-site oral test partly based on written product) but revised exam questions to ensure alignment and to demand answers on a higher taxonomic level. The outcome of the changes was positively received by students as well as other teachers on the course. Hougaard (2013) experienced ILO-AT misalignment because the exam, in practice, only aligned with parts of the learning outcomes. 75 % of the grading was attributed to a project report and the oral exam (25 %) should target the rest of the curriculum, but did not. Her solution was to shift weights between the written and oral part of the exam to equal weights. Furthermore she discusses the possibilities of introducing more formative assessment or feed-back, and hence ILO-AT alignment in a course through student reflection papers for each module (6 modules in the course), but fears that an excessive workload be put on the teachers. Hansen (2013) experiences a similar form of misalignment, where practice doesn't follow the formal course description, and too much weight is put on a report and too little on the oral examination of the curriculum. His observations did not lead to changed exam forms but to changed behaviour for the teachers not only to increase alignment but also to prevent administrative problems caused by the disagreement between course description and student assessment practice. As demonstrated in the above cases ILO-AT misalignment is not rare, but several actions can be taken to improve it. Changed exam form is only one approach. Also shifted weighting between exam elements and changed practice has been applied to improve alignment.

Summary

In summary this project finds ILO-AT misalignment in the course 'Energy Systems and Climate Change Mitigation' and discusses options and limitations to improve alignment to support deeper learning at higher taxonomic levels. The report discusses the validity and reliability of different oral and written exam forms, and the risk of plagiarism and fraud. Limitations imposed by regulation requiring individual assessment together with cost expectations narrow the field of applicable options to improve alignment. Finally the project suggests a new exam form for the course made up of two written parts: An individual un-invigilated essay based on supervised group work and a 'traditional' invigilated exam with calculation exercises and multiple purpose tests.

12

Implementation of supporting, practice-based learning activities in short geology and soil science modules in landscape architecture and natural resource management curricula

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Abstract

This study tested the use of practical exercises on campus made possible by recorded lectures as a means to create variation in basic soil science courses. Curriculum changes from one discipline to multi-disciplinary courses including soil science, geology, geomorphology, chemistry, botany, ecology, plant physiology etc. has increased the risk of subject matter overload in relation to time and textbook materials over the last decade. Soil science teachers and students expressed the need for re-introducing practical hands-on teaching and learning activities in order to achieve competencies in soil, site and landscape evaluation e.g. with respect to suitability for tree growth. Teachers on multi-disciplinary courses are encouraged to work as teams to ensure balanced teaching and learning activities and avoid overload of subject matter from competing disciplines.

Introduction

Until a decade ago teaching in soil science was central for most curricula established at the former Royal Veterinary and Agricultural University (except Veterinary medicine). Typically, it was a 9 ECTS course in geology and soil science following a 15-18 ECTS course in general chemistry and followed by several optional specialized courses. Now, the common basic course for all curricula has been replaced by smaller modules in different multi-disciplinary courses and representing a maximum of 7.5 ECTS, i.e. less than 25% of the previous volume. This has happened in the curriculum for landscape architect bachelor students. The teaching activities are now more abstract and virtual due to the reduction in allocated time. However, judged by course descriptions (e.g. NG1: http://kurser.ku.dk/course/nigk13008u/2014-2015) the intended learning objectives are the same as before. As a consequence teaching activities are now mainly lectures that tend to turn students into passive spectators. There are also theoretical exercises, but they are not well connected with the lectures, which leaves the students confused about the intended learning objectives and the summative assessment. New, condensed textbooks have been written to accommodate the curriculum changes, e.g. Ashman & Puri (2008), or can be a dense book chapter in a general ecology textbook, e.g. Chapin et al. (2011) Principles of terrestrial ecosystem ecology. These books are tailored for cross-disciplinary courses for students with no background in science, but there are various pitfalls. Either the textbooks include too many details, or have tacit assumptions of student qualifications. Such textbooks are only meaningful, if the students know the content already from other previous courses.

In short, for introductory soil science courses the frame has changed (fewer ECTS), the learning activities have changed (less field work and no laboratory work), whereas the learning objectives in some new cross disciplinary courses are ambitious to a level that could easily cover a full masters' degree:

The intended learning objectives (ILO's) with respect to knowledge, skills and competencies for the two courses on which I base this study are summarized in brief here:

> **Ecology and ecosystems science in relation to environmental economics (EESREE, 15 ECTS, master level – 1-2 weeks allocated to soil science):** *'Describe biogeochemical and soil processes...' ' analyse structures', 'make plans', 'communicate solutions'*
>
> **Naturgrundlaget 1 (NG1, 15 ECTS, bachelor level, of which 7.5 ECTS have been allocated to geology and soil science):**

- Kende centrale jordbunds- og geologiske begreber og terminologi
- Beskrive grundtræk i Danmarks prækvartære udvikling, karakteristika ved glaciale og Holocæne sedimenter.
- Kende til jordbundsdannende processer og beskrive dem.
- Beskrive jordbundens komponenter og deres betydning for jordbundens vandhusholdning og fysiske tilstand.
- Kende grundtræk af jordbundsfauna og -mikrobiologi.
- Beskrive naturlige processer der påvirker menneskeskabte terrænkonstruktioner.

The question is whether the realized learning outcomes will match the intended learning outcomes in these courses. The EESREE (http://kurser.ku.dk/course/nigk13008u/2014-2015) course is an introductory course in the master programme for environmental and natural resource economy. NG1 is an introductory course in the bachelor programme in landscape architecture. Both courses may also include elements of botany, plant ecology, systems ecology, and broad natural resource management aspects. This gives a strong competition for adding work load from each of the disciplines involved, since many teachers with different scientific backgrounds are involved. If one discipline chooses to overload the students, this may become a general trend, and the result may be a catastrophic overload of subject matter from the student perspective with no clear idea of prioritization according to the learning objectives. In the NG1 course this has been solved by splitting the 15 ECTS in two blocks, and giving up the basic chemistry that was formerly a prequalification for the geology and soil science part. According to Figure 12.1, two factors have changed without changing the ILO's: The teaching and learning activities (TLA's), the frame, and the students' qualifications.

It may be so, that course descriptions are so general that changes in actual course contents after reductions in ECTS are not visible. It also may be the case, that the teaching and learning activities become imbalanced due to content overload in cross disciplinary introductory courses. This is my hypothesis for why students often express disorientation and feel overwhelmed.

During spring 2014 I met the landscape architecture bachelor students in the follow up course (NG2) where I was also teaching some days, since the applied soil science is my field of scientific work. I saw that the students were interested and motivated, but generally unable to demonstrate

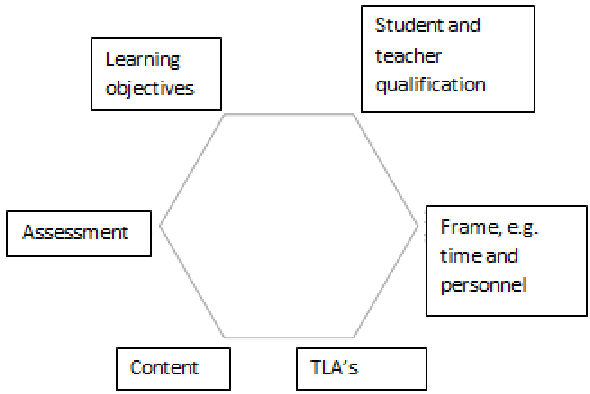

Fig. 12.1. The components of a teaching system in higher education. Modified from: 'Læring gennem oplevelse, forståelse og handling' (Hippe & Hiim 2002).

the competences they should have acquired during the NG1 course according to the ILO's. I realized the need for designing TLA's in the introductory courses that could match the needs for knowledge, skills and competences of the follow-up courses in the curriculum.

With this prehistory of a reduced time frame, one option for a teacher could be to give many lectures and present as much subject matter as possible within the very limited time frame in both courses. I did not believe that it would be a fruitful strategy. It would be better to plan the course content again by posing the question: "If natural science as a discipline is central for both these curricula, how can it be assured that most of the students get familiar with scientific method and creation of knowledge in the subject fields ?" They will be users of such knowledge in planning and designing landscape resources either physically or economically in their professional life. It became clear to me that practice-based experimentation and thus teaching and learning activities including this element are one of the main characteristics of scientific method and teaching in science. This is not mentioned in the course descriptions, rather it seems to be a tacit assumption, that student know how scientific knowledge is created.

Aim and problem

In this project I will investigate the implementation of practical exercises aimed at supporting active learning in geology and soil science taught in condensed course modules with long days (half day plus full day in the block structure) as part of cross-disciplinary courses. The intervention is to introduce practical exercises to students in two courses (EESREE and NG1) that were not intended to have them in the first place, that is, to include practical activation in teaching modules that could otherwise easily be filled with massive lecturing causing passive student behavior – the spectator syndrome (Herskin 2001). One of the issues in conducting practical exercises as group work is the demand for manpower. It will therefore be investigated whether learning outcomes are affected by the presentation order: Are audiovisual pre-recorded lectures a useful TLA in providing 'unmanned' teaching for one half of the class (65 students in total), while the other half is carrying out practical exercises ? Will the order of activities affect the learning outcome?

Pedagogical theory

According to the teaching system depicted in Figure 12.1, intended learning objectives, subject content, assessment methods and TLA's should form a harmonic system no matter the length of a course or module. Practical exercises are not required to meet a specific competence in the ILO's. It would be perfectly alright to lecture and ask the students to memorize concepts from textbooks and rephrase them for an oral or written exam. However, the practical exercises would be supporting activities in order to secure that higher education teaching with a constructivist approach is research-informed and may also be research-based at the basic level (Griffiths 2004, Butcher et al. 2006). The 'Learning by doing' is a well-known concept from scouting, sports, music and other training – and also in the academic curriculum such supporting activities are finding their place. Even though we are not training scientists in introductory courses, it should be clear how scientific knowledge is brought about. According to (Biggs & Tang 2011*b*, Table 4.2, p. 63), the notion that *doing* things supports the learning much more that *hearing* subject matter is attributed to the psychiatrist William Glasser (1925 - 2013).

The timeframe for my teaching did not allow for teaching scientific method and the experimentation behind the established accepted scientific knowledge (i.e. research-led or research-oriented teaching), and this was not the objective either. Instead I learned that *guided inquiry* is a method to mimic such activities; to train students in this mindset – how knowledge is created. A peer or the teacher shows some objects, and asks students to propose actions to explore and demonstrate a certain mechanism, concept or idea (Lewis & Lewis 2005). The teacher guides the students' recognition of a phenomenon and let them construct their knowledge by themselves.

Students can be trained to memorize and use textbooks and recapitulate them at an exam using a surface approach. In this context it is interesting whether the practical exercises can support a deeper learning and also when theory should be introduced – before or after the exercises.

Methods

1. **Pilot-study. Development and test of practical exercises**. During the EESREE course for fresh Master students of Natural Resource Economy one full day was assigned to soil science, which I was responsible for. I planned an intervention including 1.5 hours practical exercises involving observation and measurement of some soil properties (pH, texture, soil colour, bulk density, Appendix A6) from different land uses after an introductory lecture. After the day I asked the students to fill out a short survey to test their learning, their own impression of their learning, and their view of the different TLA's presented during the course.

2. **Survey among soil science teachers** on how to develop course contents from the previous 9 ECTS courses (+15 ECTS chemistry) with a clear focus on soil chemistry to shorter courses, e.g. in NG1 and EESREE with no further qualifications than the uptake criteria for the bachelor education in landscape architecture (Mathematics A and Chemistry C). With this survey, I wanted to get an overview of the different views on the changes and reductions, and retrieve inspiration how to design compressed geology and soil science subject matter teaching in the future.

3. **Intervention in TLA's on the NG1 course – theory or practical exercise first? Learning** landscape formation - the process of recognizing the dynamics and the time scale of landscape formation is a chal-

lenge for many students. I designed some hands-on exercises showing the action of glaciers (frozen 1 liter ice blocks with stones etc., see Appendix A7), water and wind on sediments as a background for analyzing landscapes and land forms in Denmark. The group of 65 NG1 students was split in two classes. One half first watched an audiovisual pre-recorded lecture, while the other half took part in an outdoor session in groups of four with hands-on small scale experiments in formation of the glacial landscape. The two classes switched activity after a short break. After the two TLA's the students took a short formative test in order to assess their learning. The use of a prerecorded lecture made it possible to offer the practical exercises with limited personnel and material resources.

Results

The following is a short summary of important outcomes from the three surveys included as appendices.

1. **Practical exercises for EESREE students**. Examples of the outdoor exercises are illustrated in Figure 12.2 and Figure 12.3. After the exercises the students filled out a questionnaire. 15 responses from 34 possible respondents were obtained. The students were asked how well they remembered a field excursion, some lectures and the practical exercises. The students clearly remembered what they did during the field excursion and the practical exercises and less so, what happened during the first morning lecture. However, the students remembered more content from the morning lecture than from the last lecture during the afternoon. They specifically selected field excursions and practical exercises as TLA's they would like to do more. When asking about the central learning objective, i.e. Jenny's conceptual state factor model for soil development, they remembered on average 3 (2-4, 95% confidence limits) of the 6 factors in the model. Three respondents remembered none of the model factors climate, organisms, relief, parent material, time and man. The latter observation was somewhat surprising to me.

2. **The soil science teachers participating in the survey dealing with basic geology and soil science in the NG1 course were asked the following questions (answers in Appendix, pages 10-20)**:

a) Are first year students with the mentioned background from gymnasium (Matematik A, Engelsk B, Fysik B og Kemi C) capable of using the chemistry they should know to study basic geology and soilscience as outlined in the learning outcome below (see page 1)?
b) Which topics are the easiest for students to learn - pick three
c) Which topics are the hardest for students to learn - pick three
d) Choose teaching and learning activities that would think are indispensable in meeting the learning objectives (choose as many as you like)
e) Given limited resources (time and personnel) choose three teaching and learning activities that can be discarded with only little loss in the students learning outcome?
f) Which of the below publications would you find suitable for basic teaching of soil science at university level? Please, rank the following textbooks in order of their suitability for basic teaching in soil science and value for money.
g) Which of the below textbooks (within the same 7.5 ECTS course) would you find suitable and choose for basic teaching of geology and geomorphology at university level for first year landscape architects? Please, rank (1-2) the following (see A2)
h) Students can choose their own textbooks according to the university reform. Is it OK to use and recommend material from encyclopedias on the internet to students?

I invited 17 soil science teachers and got 9 responses. The most univocal answers were that soil chemistry is the hardest topic for students to learn (Q2), and that field work is indispensable (Q3), whereas drawing exercises can be discarded (Q4). When it comes to choosing text books some of the short ‘layman prose’ textbooks currently used were given low priority in terms of suitability and value for money in comparison with more detailed textbooks, e.g. the standard American 800 page textbook (Brady and Weil: The nature and properties of soils). Also notable was, that the teachers participating in the survey disagreed in their answer to many questions, e.g. whether students have sufficient background from secondary school (Q1 50% said most, 25% some students had sufficient background).

3. **Intervention in the NG 1 course – development of practical exercises**.

The NG1 landscape architect students were split in two classes – one class received practical exercises with an intended 'guided inquiry approach' followed by an audiovisual lecture. The other class first watched the audiovisual lecture on the topic the glacial landscape and then carried out practical exercises in groups of four with one teaching assistant for each of four activities. During the exercises, some of the students in the groups were enthusiastic and active, but some were also passive.

The assessment of the learning outcome showed that the average percentage of correct answers did not differ between the two groups (75% versus 77% correct answers, Table 12.1). Answers to question 9 on the definition of the onset of the Holocene were more correct in group 2, due to the content of the question, being better explained in the lecture. To my surprise, there were some incorrect answers to questions that I assumed would be 100% correct. An oral exam or an essay type written exam would be better suited to test how well students perform according to assessment criteria (these had not yet been formulated). This type of formative assessment can guide the need for e.g. prioritizing important learning objectives.

Fig. 12.2. NG1 students working exploring water movement in soils on campus using a sponge as a model. Photo Pia Lund-Nielsen.

Fig. 12.3. Soil pH measurements and using field kits - which soil samples belong where ? Photo Pia Lund-Nielsen.

Table 12.1. NG1 survey of practical exercises before or after lecture

Percent correct answers	Group 1 Audiovisual before practical exercise	Group 2 Practical exercise before audiovisual lecture
Started surveys, N	21	20
Completed surveys	18	19
Q1	100 %	95 %
Q2	72 %	100 %
Q3	100 %	100 %
Q4	78 %	67 %
Q5	72 %	72 %
Q6	100 %	83 %
Q7	89 %	72 %
Q8	39 %	44 %
Q9 Holocæns begyndelse defineres som Overgangen fra Yngre Dryas til Præborealtiden	29 %	61 %
Average (t-test, H0: same avg., P=0.89^{NS})	75%	77%

Discussion

The teacher survey confirmed my speculation that keeping ILO's constant, while reducing resources vastly, have caused problems in the teaching system. Cancelling resource demanding practical exercises and field excursions may cause loss of alignment, e.g. loss of competencies. The results of the active learning efforts in the practical exercises will appear after the exam in January 2015 (EESREE), and by observing how well the landscape architect students perform in the following NG2 course in spring 2015.

The pilot study for EESREE, the teacher survey and the main intervention for NG1 showed that practical exercises and field excursions can be incorporated effectively in short modules giving more variation in long course days. Students and teachers agree on their importance of practical exercises and field work (received 35 % of the teachers' votes and 50% of the students' votes).

Using guided inquiry as a student activation activity takes time and requires an experienced teacher who knows when to intervene with validating knowledge. There was a tendency that the exercises due to the short time allocated to them (15 minutes to each of four exercises) could develop into a mini-lecture by the teaching assistants. Patience and time is required, letting the students explore the 'game' and develop their own theories.

The question whether active learning should take place before or after lecturing (e.g. Westermann & Rummel (2012)) is not the key issue here. It was a practical circumstance, allowing for active learning with groups and smaller size classes.

Course descriptions should include knowledge, skills and competencies described in detail along with assessment criteria, and the type of teaching activities should also be spelled out with some detail. Only then, the students can use the course description for guiding their study activities and setting their level of ambition. It is obvious that teamwork among teachers is needed in cross disciplinary courses. Whether this happens seems to be the responsibility of the course leader. There is a risk, that cross-disciplinary multi-teacher courses become serial mono-disciplinary courses. Team based teaching is an emerging challenge to be followed up.

Based on the experiments with teaching formats here, I suggested new assessment criteria to the new course description in November 2014 for NG1. The course has a written exam with all aids allowed (40% weight) for the geology and soil science part. The criteria are:

- "describe landscapes and landscape formation based on geological and geomorphological processes with relevance for Danish conditions"
- "evaluate soils and their suitability for tree growth"

The learning activities in the practical exercises were directly designed to train these criteria, and a better alignment between learning objectives, teaching activities and the final assessment should hopefully result. In order to examine the effect of practical exercises on the EESREE course, a dialogue with the teachers responsible for the final assessment is needed. Positive student evaluations may not reflect their actual realized learning outcome as seen in the EESREE survey.

Conclusion

From the students' perspective, my pilot study on the EESREE students showed that students want more field excursions and practical activities. A full day of lectures and theoretical exercises may cause an information overload, while some hands-on activities in-between can give other, supporting stimulation in the learning process and make the teaching research-oriented, especially if the guided inquiry approach is involved.

The intervention in the NG1 teaching with landscape architecture bachelor students turned out to show that the order of the two – theory first and exercises after or vice versa did not affect the test results. Both groups performed well in answering the test questions. I therefore conclude that audio-recorded lectures can be the activity that in fact allows for inclusion of intensive and direct interaction with only 20-30 students in small groups performing practical exercises as a supporting, active learning activity. This activity allows for developing the guided inquiry approach further.

The block structure with short term intensive courses requires new teaching plans involving diverse teaching and learning activities – continuing the old format and preserving only the lectures and theoretical exercises may cause overload of subject matter. It has proven difficult to find suitable textbooks. Teachers and students agree on the need for diverse activities including field excursions and practical exercises. This study suggests that hands-on activities are valuable and can be fitted into the current week schedule. Future improvements in assessment criteria and final assessment formats in the EESREE and NG1 courses (e.g. an oral exam based on a project report) will show, whether the individual student performance actually improves as a consequence of more activating, practical teaching and learning activities.

A Appendices

Appendices can be downloaded as one file at http://www.dansoil.dk/Filer/A1_to_A7_merged_document.pdf

A1: EESREE survey of student reflections on TLA's in one-week module on soil science in a 15 ECTS course. Page 1 - 10 in pdf.
A2: Teacher survey of choosing course literature and TLA's - results. Page 10 - 20 in pdf.
A3: NG1 survey - assessment of terminology and processes in the glacial landscape by 1) audiovisual lecture followed by practical exercise, or 2) practical exercise followed by audiovisual lecture. Page 21 - 40 in pdf.
A4: EESREE course description(http://kurser.ku.dk/course/nigk13008u/2014-2015) 5070-B1-2E14; Ecology and Ecosystems Science in relation to Environmental Economics. Page 41 - 42 in pdf.
A5: NG1 course description (http://kurser.ku.dk/course/nigb13001u/2014-2015). Page 42 - 43 in pdf.
A6: Practical soil science exercises for EESREE. Page 44 - 47 in pdf.
A7: Practical landscape formation exercises for NG1. Page 48 - 51 in pdf.

Part III

Promoting deep approaches to learning

13

Promoting deep learning in mathematics through conceptual exercises

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Abstract

We investigate the effects of posing non-traditional "conceptual" problems to university mathematics students as a means of promoting a deeper level of learning among a class of second year undergraduate mathematics students at the University of Copenhagen.

I. Introduction

(A) Background. The traditional and still dominant mode of teaching mathematics at almost all levels of education in Denmark, and the Western world at large, divides the learning process into two separate steps:

1. Introduction of the theoretical material and main examples in a lecture format and through supporting reading material (textbooks, and, frequently at the university level, tailor-made lecture notes).
2. Consolidation of theoretical knowledge introduced in Step 1 and development of problem-solving skills by working through problems and exercises[1] (usually as homework).

[1] Problems and exercises in mathematics often ask students to calculate a quantity or, in higher level classes, to prove (using logical reasoning) some mathematical fact.

Step 1 has the singular goal of imparting *knowledge* on the students. By contrast, Step 2 has two *distinct* goals, the first of which, *consolidation*, is often described as "checking the understanding" when mathematics teachers describe Step 2, while the second goal is to promote the learning of a *skill*, namely, solving mathematical problems and exercises.

Regarding Step 2, the traditional belief is that it (a) forces students into an active role in relation to the theoretical knowledge, and that (b) students cannot succeed at Step 2 without understanding the theoretical knowledge from the lectures and the textbook.

It is widely acknowledged by mathematics teachers that (b) above is somewhat dubious. At lower levels, here meaning up to and including the second year at university, many students 1 Problems and exercises in mathematics often ask students to calculate a quantity or, in higher level classes, to prove (using logical reasoning) some mathematical fact. take a "plug-and-chug"[2] approach to Step 2, meaning that they aim only to develop the skill of solving standardized problems, and ignore the loftier ambition of using Step 2 to develop a deeper, consolidated understanding of the theoretical material of the course (the focus of Step 1).

(B) The problem with "plug-and-chug". The discussion in (A) above suggests that the 2-step model described there suffers from the serious defect that for many students, Step 2 only will accomplish half of what it was intended to. But aside from the fact that the surface learning resulting from the plug-and-chug approach is a "no-no", frowned upon in the ivory tower of Academia, one may wonder how serious a problem this really is. Many students will tell you that they successfully made it through required math classes (even at the university) by learning to do standardized problems and reproducing this skill at the final (usually written) exam.

If the students in questions are *not* math majors, e.g., are engineering or life-science students, then the seriousness of this problem might well be limited. That being said, a real problem *does* arise when *math majors*, that is, students who are pursuing a degree in one of the mathematical sciences, take the plug-and-chug approach. The experience in Copenhagen is that the problem becomes evident when these students enter into the Master's program where they start to struggle, and it comes to a head when they must write their Master's thesis.

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[2] The term plug-and-chug (or plug 'n chug) for this surface learning approach is in common use among American engineering students.

Let's be very clear about what the problem is: The very best students in mathematics invariably develop a conceptual understanding in which the mathematics comes to live in their mind as a blend of (a) knowledge of key facts (theorems) and their interdependence, (b) key examples that illustrate possibilities and limitations of the theorems, and (c) mental images (see the discussion in Hadamard (1973)) attached to the key facts. Students who have engaged in a plug-and-chug surface approach are on shaky ground with (a), and usually lack (b) and (c) entirely.

(C) Non-traditional exercises for promoting conceptual learning. The project at hand describes an attempt at giving students in a second year mathematics class ("DIS", discrete mathematics, 60 students enrolled, 7 weeks of instruction with 5 hours of lectures per week and 3 hours of discussion section per week, oral final exam, taught in the fall of 2014) at the University of Copenhagen a non-traditional kind of problems to work with in order to promote conceptual learning.

The format of these problems were often "describe in your own words, using everyday language, what — means", where — is a key concept discussed in the class. On five occasions, students were given non-traditional problems:

- On the first day of lecture, three non-traditional problems were posed on a slide for the students to work with for 10-15 minutes before they were discussed in the class.
- Twice, non-traditional problems formed part of the weekly homework assignment.
- The course had two required (for passing) hand-ins, both of which included nontraditional problems.

(D) Organization. The report is organized into five sections, including the introduction. In section II, we will briefly review some of the background and literature on the subject of promoting better learning through non-traditional approaches to teaching mathematics, and in particular, we will consider a report from Høgskolen i Østfold, Norway, from 2004 by Marianne Maugesten and Per Lauvås, on a new approach taken to teaching mathematics to education students (lærerseminarstuderende). In section III, we describe in some more detail the specifics of the current project. In section IV, we will report on interviews conducted with two students (one pure math student, one statistics student) from the class DIS after the class had ended. Finally in section V, we will try to sum up our observations and conclusions about the effects of posing non-traditional problems to mathematics students.

II. Some new approaches to the teaching of mathematics

The impetus for the form of the present project comes from two sources: A study done by Maugusten and Lauvås (Maugusten & Lauvås 2004) and from work done in my pædagogikum pre-project (Holst et al. 2014).

II.1. “*Better learning of mathematics by simple means*?”. Maugusten and Lauvås from Høgskolen i Østfold, Norway, reported on a project called “Bedre læring av Matematikk ved simple midler?” in 2004, see (Maugusten & Lauvås 2004).

The main problem facing Maugusten and Lauvås (Maugusten & Lauvås 2004) is that students of education (training to be schoolteachers) were failing a class on basic mathematics and teaching mathematics at alarmingly high rates (>50% fail rate). Seeking to remedy this situation, they sought inspiration in a successful restructuring of a basic math course taught at DTU (Denmark’s Technical University), and restructured the math class with the high failing rates.

There are three main features of the Maugusten & Lauvås (2004) approach[3]:

- Students must through the course produce a “portfolio” (workbooks) with solutions to various problems posed in the class. (This part is lifted directly from the DTU approach).
- The students have to give each other feedback on their portfolios. This part is motivated by considerations of Gibbs (Gibbs 1999). The authors argue on this background that receiving *frequent and timely feedback* is highly motivating. It is more important, they believe, that feedback be delivered before the students move on to another topic than that it carries the stamp of authority of the teacher.
- Finally, the authors decide to at least in part focus on *open ended* questions that ask the students to explain concepts in everyday language, rather than only giving them traditional problems.

[3] It is also part of the ML approach that the students are divided into three groups based on their level in mathematics (“niveaudifferentiering”). This part is surely relevant for the success of the approach, but is only tangentially relevant to the direction of the current project.

It is the last point that is particularly relevant to the present project. Some examples of questions they give the students are:

> *"What does it mean that two triangles are congruent?"*
>
> *"What does the formula [sic] 2πr express? (Write with your own words)."*
>
> "Define with your own words: i) sin v, ii) cos v, iii) tan v."

The results are in line with what had happened at DTU: The fail rate fell from 54% to 15%, and the group of students receiving the lowest passing score fell from 66% to 20%.

Student interviews were conducted, and the students were overwhelmingly positive about all aspects of the approach. The students feel that the new approach forces them to work more, and that the peer evaluations gives them an understanding of how easy it is to think about a mathematical concept in the *wrong way*, something that they perceive as positive.

II.2. "*Bridging lessons with online quizzes*": This is the title of the author's pædagogikum pre-project from the spring of 2014, conducted and written together with Peter Holst, Linda Udby and Anja Wynns (Holst et al. 2014).

In this project, we were aiming to find a way of making lectures feel less disconnected by giving the students quick online quizzes that they had to do between two consecutive lectures. The quiz questions were to be such that their answer relied on the knowledge of the previous lecture, but also pointed forwards to topics of the next lecture.

It turned out to be very difficult to come up with traditional math problems that had this feature of pointing both to the previous and the next lecture. For this reason, I started asking conceptual questions on the online quizzes instead.

Thus the quiz questions ended up, somewhat by accident, taking a form very similar to the conceptual question of Maugusten and Lauvås. When students were interviewed later, they were overwhelmingly positive about the quizzes, but more than anything, they were pleased that the conceptual questions had helped them direct their thoughts to start *forming* the correct concepts. The questions had caused the students to spend much time pondering the key concepts of the course, and it had motivated discussion between the students outside the classroom.

III. Conceptual, untraditional problems and the course DIS

We now turn to describe the specifics of the non-traditional problems given to the students in the course DIS.

(a) In the first lecture, students were introduced to problems having a non-traditional format on a slide, and asked to work on three specific untraditional problems. To give an example, one of the problems asked:

- Describe in your own words what it means for a set of numbers to be closed under the operation of subtraction? Which of the sets $\mathbf{N}$ and $\mathbf{Z}$ are closed under subtraction?

The students were given 10-15 minutes to work either alone or with the students next to them on three problems of this form. After this, the answers were discussed in class.

(b) During the second and fourth week of classes, students were given a sheet of conceptual questions to work on as part of the assignment for their weekly discussion section. The questions were then discussed by their Teaching Assistant in the discussion section. An example of one of the questions (from week 4) is:

- Explain in your own words why it is reasonable to say that two sets A and B have the same number elements if there is a bijection between them. Do you also think this is reasonable when A and B are infinite sets?

(c) The students had to hand in two mandatory assignments that they had to hand in and have marked and approved in order to be eligible to take the exam.

On the first of these assignments, due on the third week of classes, the students were asked to consider two seemingly different proofs of the same theorem from lecture. They then had to explain informally using everyday language what was going on in two proofs (what the "idea" was in each case), and try to make a drawing to illustrate. The goal was that the students discover on their own that the two seemingly different proofs actually represented the same underlying mathematical idea, just dressed up in different formal guise.

In the second mandatory assignment, due in the fifth week of classes, the students were asked to prove Ramsey's theorem (a combinatorial principle first discovered in the 1930s). The task was broken down into steps for the students in the exercise. The first step asked the students to give an informal argument for the following statement: "If at least six people are present at a party, there must be at least three people at the party who either have never met before the party, or three people who had all met at some time before the party". The next step presented the formal statement of Ramsey's theorem, and asked the students to explain informally why the "Party Problem" is a special case of Ramsey's theorem. Finally the students are asked to draw on their informal argument for the Party Problem to give a formal proof of Ramsey's theorem.

IV. Interview with two students

To investigate the student's perception of the non-traditional problems posed in the course, two students were interviewed after the course ended. An interview was scheduled with a third student, but this student didn't show up for the interview, and did not subsequently respond to emails.

The students interviewed are:

- Student M, a statistics major[4]
- Student N, a pure math major.

Student M and N both successfully passed the course: M received the mark 7 at the oral exam, N received the mark 12. They were interviewed separately four days apart.

The interview opens with some brief background discussion of which activities they feel they get the most out of when learning. Student N emphasizes going to lecture and taking good notes, in particular of "the things that are said but not written down anywhere". Student M says reading the book very carefully is the best way to learn.

Q: What about exercises and going to discussion section?

Both students agree that the usefulness of discussion section varies. They both try to read the exercises before going to discussion section, but rarely

[4] Student M requested anonymity in order to participate in the interview.

have time to work through them. Student N emphasizes that "doing exercises helps with the understanding", and adds "you use it [the theoretical knowledge]". Student M finds that the Teaching Assistants are very skilled, but feels intimidated by the difficulty of the problems and exercises: "the two discussion sections are too similar. Both have a very high level. One should be on a lower level and the other on a higher level for those students who want that".

Student M adds: "I take a sloppy approach to solving the [traditional] exercises. First I read what it says, and then if I don't understand every word, I have to go back and read again how it is all connected. You have to have an overall grasp before you can approach the exercises [...] I am good at getting ideas, but when I finally get an idea down, it takes too much time to work out the details. I would rather wait until I can ask someone else [how to do it]".

Q: During the course, I gave you some exercises that were a little bit different from the usual. What do you think of this kind of exercise?

Student N: "I remember those problems very well. The first one we got for the mandatory assignment was very difficult, and I was very tired of that problem. But it was a really, really good problem if you wanted to understand what really goes on. The reason it was so irritating was that your notes were so difficult to read".

Student M: "The attitude most people had to this problem [the non-traditional problem on the first mandatory assignment] was 'this is something we haven't tried before'. It was difficult to find out what you wanted us to do... we talked about it, and about which drawing you could make, but we couldn't figure it out."

"The other [second] assignment was better, because you could easily make a drawing, and then afterwards you could use it to make an argument."

Q: There were other untraditional exercises...

Student N: "Yes. They were really good, because it becomes informal, and if you don't understand the formal mathematics, then it is probably because you don't understand the informal. [...] I like the informal things a lot, the side remarks in lecture and discussion section, because it gives you a feeling of what you're working with instead of just definitions and theorems."

Student M doesn't initially remember there being other non-traditional exercises in the course, so to refresh the memory the ones from week 2 and 4 are shown.

"They force you to think along different lines than what we are taught to do in this place. So it is a challenge. But I don't like them, because my perception is that a theorem is the justification of some maneuver. The proof is just something we learn so that we know that the theorem is true. It is very unpleasant when you have just learned a new theorem to have to relate to it in this way [of the non-traditional exercises]."

Q: The non-traditional exercises focus more on concepts than on doing formal mathematics. Do you think learning to do this kind of exercise is important going forward, as you start taking more advanced classes?

Student N: "For sure. Even without this type of exercises, if I see a definition I don't really understand, I want to find something more concrete, to put it in a box, so I will remember it. But it is nice to get some help with this process, because it takes so much time to do it alone. But the more you do it, the better you get at thinking in this way".

Student M: "It is probably something that becomes more important later. But it is very different in statistics and math classes. In statistics, you just want to see [in lecture] how the analysis is done, and which words they are using in lecture. In the math classes, you need to take everything apart to learn it. I can't always cope with that, so this is what I need more help with."

The students are asked if they would like more conceptual exercises. Student M says "no", and adds that "they would be better to get at the end of the course". Student N says "yes", and adds: "for the discussion section, preferably every week. We don't need it in lecture where other things are more important. But they are nice because the [traditional] exercises are like 'prove this'. Then I get stuck. But if you get 'explain this', then it is much easier to get started."

Finally, I ask if the non-traditional exercises help them remember the material from the course better. Student M feels that a review of the material at the end of the course would be more helpful. Student N says "Completely!

It gives you a sense of having a perspective of what really goes on, and then the formal mathematics is just a certain way we have to work, but to have a perspective which isn't just about formulas and symbols."

V. So what?

The problem posed in the introduction was if a non-traditional question format would promote conceptual learning among students in the class DIS, and steer students away from taking a surface learning approach. The motivation for doing so is a rather difficult to measure long term goal: To make the students better prepared for Master's level study.

Some facts: Of the 60 students enrolled, 54 took the oral final exam, and 53 passed. This is a vastly higher success rate than the course has had before (previously, around 15% of students have failed at the exam), but it is impossible to know what the reasons for this is[5]. Many students used what they had learned from the non-traditional exercises in their presentation during the oral exam.

Having just two student interviews to go on, drawing any sort firm conclusion about the effectiveness of the approach from what has been described above would certainly be a fallacy. All the same, the experience suggests some key points:

- The effectiveness of assigning traditional exercises may be severely restricted because the students find them too hard, and don't have the time to actually do them.
- The non-traditional exercises seems to have the advantage that they are easier to approach.
- The students feel unsure about what is expected of their answers when doing nontraditional exercises. This seems to be a cultural issue: They have never met this form of exercise before. It also suggests the importance of giving the students timely feedback on the non-traditional exercises.
- The apparently stronger student is far more enthusiastic about what is gained from thinking informally about the material (in general), whereas the apparently weaker student is far less enthusiastic.

[5] The author feels that 3 or 4 more students should have failed, but could not reach agreement with censor (the external examiner) to fail more students. Censor later conceded that he was too lax.

- The students acknowledge that in the future, their may be a value in having learned to do conceptual exercises.

Based on the experience, my recommendations are:

- Non-traditional exercises are a useful learning tool that challenges the students to approach the material differently, but the students are not used to this type of exercises, and will need to get clear feedback in order to learn how to do them, and feel confident about their answers.
- Incorporating them into the weekly exercises seems the most productive way for the students to benefit from doing these exercises (and gaining routine doing them).
- Finally, by paying close attention to how the students deal with the non-traditional exercises, the teacher gets a new and valuable source of information about how the students are doing in the class, and which concepts are causing the most difficulty for the students.

14

Det Ansvarsfulde Vejledningsforløb - Inklusion og opgavevejledning af bachelor- og kandidatstuderende som tager aktiv del i et forskningsprojekt

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Abstrakt

Vejledning af bachelor- og kandidatstuderende frem mod deres afsluttende opgave og mundtlige forsvar heraf skal ses som en undervisningssituation. Dvs. vejlederen skal planlægge et UV-forløb, der ender med studentens leverancer. I henhold til John Biggs' constructive alignment (CA)-teori, hvor der er høj grad af overførbarhed mellem undervisningsaktiviteterne/de stille opgaver og det endelige produkt/eksaminationen, er det afgørende, at vejledningen af studerende, som følger et forskningsprojekt samtidig med deres opgaveudarbejdelse, følger en nøje planlagt progression og fører den studerende i lige linje frem til mål. I denne opgave præsenterer jeg en evaluering af et teoretisk baseret CA vejledningsforløb, som jeg applicerede på tre bachelorstuderende i foråret 2015. Evalueringen foregik retrospektivt i semi-strukturerede interviews. For at opnå fuldt fokus på opgaveudarbejdelsen skal de bedste rammer for et sådant tidsbegrænset og oftest travlt forløb være til stede og dér er inklusionen af den studerende i forskningsinstitutionen afgørende. Opgaven indledes derfor med konstruktion af et forløb for inklusionen af studerende på en forskningsinstitution. Inklusionsforløbet er udarbejdet med baggrund i teorien om inklusion og efterfølgende justeret ind til målgruppen via en spørgeskemaundersøgelse blandt bachelorstuderende på medicin samt et recall interview af en kandidatstuderende. Inklusionsforløbet er herefter anvendt på de tre bachelorstuderende, som efterfølgende evaluerede inklusionen.

Motivation for undersøgelsen

Personligt har jeg ikke tidligere opfattet vejledningen som en undervisningssituation. Men i min efterrationaliserende proces på universitetspædagogikum ser jeg nu vejledningssituationen som en (og måske endda den ypperste) øvelsessituation, der samler enkeltdelene af studiets essentielle faglige områder. Vejledningssituationen og opgaveudarbejdelsen i denne forbindelse er således det tætteste de studerende kommer på den virkelige akademiske arbejdsmåde i deres studietid – og er derfor den situation, hvor de skal demonstrere deres akademiske evner og dermed udbyttet af hele deres uddannelse. I den studerendes arbejdsproces frem mod dette afsluttende værk, er det vejlederens ansvar dels at sikre en tryg inklusion af den studerende i eventuelt nye omgivelser, så processen kan få fuld opmærksomhed og dels at undervise eller måske rettere træne og sparre den studerende i produkt og eksaminationsleverancerne.

For at give den studerende den mest virkelige indsigt i akademias arbejdsmetoder, er det derfor nødvendigt at vejlederen tillægger vejledningssituationen og -forløbet en grundig overvejelse og indsats.

Vejledningssituationen

Vejledningssituationen adskiller sig fra traditionel undervisning ved at være en direkte én-til-én kontakt – mellem underviser og studerende. Denne opgave retter sig mod vejledningssituationen af studerende, der har valgt et ophold på en forskningsafdeling, hvor de inkluderes som medarbejdere i et forskningsprojekt. De studerendes tveæggede situation er skitseret i Figur 14.1 som to arbejdssøjler. De er væk fra studiemiljøet – ude i den virkelige forskningsverden – de får lejlighed til at være medarbejdere i et forskningsprojekt og så skal de samtidig skrive deres opgave og afslutningsvis oftest forsvare den ved en mundtlig eksamination. De har med al sandsynlighed kun begrænset kendskab til deres vejleder og dennes arbejdsmetoder og forskningsområde.

Ved eftertanke, er min egen vejledning i ovennævnte skitserede situation (og sandsynligvis mange andres) præget af stort fokus på involveringen og gennemførslen af forskningsprojektet – dvs. søjlen PRAKTIK i Figur 14.1. Fokus er på at sikre, at den studerende løser den stillede opgave pålideligt og genererer pålidelige resultater. De studerende synes ofte det er spændende og nyt og så er det en skarp forskningssituation. Sat på spidsen, kan det påstås at opgaven (bachelor eller kandidat) – søjlen TEORI i

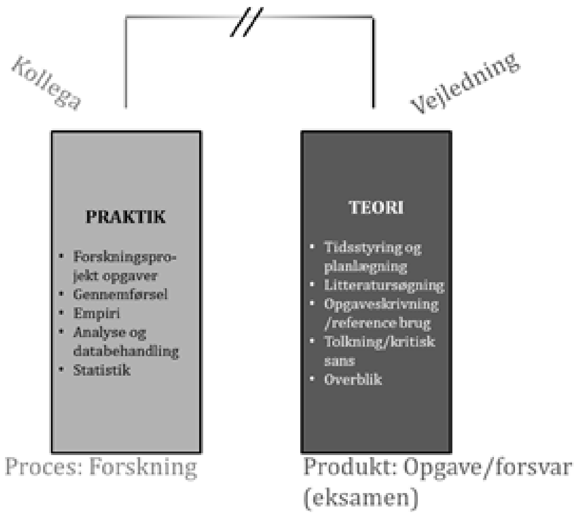


Fig. 14.1. Arbejdssøjler for den bachelor-/kandidatstuderende under et ophold på en forskningsafdeling under opgaveskrivningen. De to søjler behøver ikke have et fagligt overlap. F.eks. kan den studerende skrive en oversigtsartikel om et emne mens det praktiske arbejde går på at deltage aktivt i et forskningsprojekt.

Figur 14.1, negligeres, i hvert fald i begyndelsen! Den får den studerende vel bare skrevet hen ad vejen. Det er jo deres opgave! Og forsvaret, ja det må de jo selv sørge for at øve sig på!

Min bekymring er, at de studerende i mange tilfælde ender med at være tilfredse: De får en masse spændende praktiske erfaringer og indsigt i forskningshvervet og netop derfor overses det, at de faktisk bliver glemt som studerende i et (undervisnings)forløb frem mod et produkt i form af en skriftlig opgave og et mundtligt forsvar af denne – dét de jo bliver bedømt på. Deres specialeperiode bliver derfor mere en virksomhedspraktisk oplevelse eller i bedste tilfælde en mesterlære i den praktiske forskningsgennemførelse – end et veltilrettelagt undervisnings- og læringsforløb, som integrerer studiet praktiske arbejdsmetoder og teori: Valg i forbindelse med studiedesigns, dataindsamling, analyser, tolkning af resultater, kritisk faglig sans og perspektivering. Hvis indholdet for undervisningen af den teoretiske del ikke ekspliciceres kan jeg være bekymret for, at det bliver en implicit vidensudveksling med stor risiko for misforståelser og måske værst; at læringen bliver tilfældig og afhængig af den enkelte studerendes personlighed og påtrængenhed.

Antages det, at vejledningen i TEORI søjlen er at opfatte som undervisning, så SKAL den studerende træde ind i et velstruktureret og velovervejet forløb. Den PRAKTISKE del formoder jeg der oftest er styr på: Der vil være en eller anden form for veltilrettelagt træning i de videnskabelige arbejdsprocesser, der generer ny viden og indsigt indenfor et specifikt fagligt felt, således at dette sker tilstrækkeligt pålideligt. Det komplette vejlederansvar fører den studerende gennem en fuld arbejdsproces i akademia – og derfor SKAL TEORI søjlen (Figur 14.1) have lige så stort fokus hos vejlederen. Fokus i denne opgave er derfor vejledningen i TEORI søjlen. At arbejde med dette vejlederansvar i denne opgave giver mig mulighed for at definere opgaverne for den ansvarsfulde vejleder, formulere de spørgsmål der skal stilles, undersøge de studerendes svar og holdninger til disse spørgsmål og der ud fra komme med forslag til, hvordan den ansvarsfulde vejleder kan tilrettelægge vejledningsforløbet – under individuel hensyntagen til den studerende og med blik for deres ambitionsniveau og akademias teoretiske krav.

Baggrund

Bag hjernens evne til at tilegne sig ny viden, dvs. læring, gemmer der sig dynamiske processer, som er under konstant modulering og således til enhver tid fremstår i en balance. Det kræver en aktiv tankevirksomhed hos det enkelte individ at forstå og tilegne sig viden. Indlæring kan således ikke foregå i en passiv, inaktiv tilstand – men kræver som det mindste en bevidst åbenhed til læringsprocessen. Dog ikke ment, som at vi kun kan lære dét, vi er bevidste om. Men for at lære må vi tilgå vores omgivelser med åbent sind og med en villighed til at observere og lade os påvirke. Om påvirkningen så foregår enten bevidst eller ubevidst har nødvendigvis ikke den store betydningen for selve læringen (Rienecker et al. 2013, s. 65f). Den implicitte/ubevidst læring hører fortrinsvis til i den behavioristiske praksis om kultur, normer, værdier, o.lign., hvilket i høj grad eksisterer i akademia – og ikke mindst foregår i vejledningen i forbindelse med PRAKTIK søjlen (Figur 14.1) (et direkte sammenspil mellem den seniore forsker, mesteren, og den studerende) (Rienecker et al. 2013, 2005, s. 66f, s. 26f). Den eksplicitte læring burde herske i forbindelse med vejledningen i TEORI søjlen (Figur 14.1). Ydermere deler jeg opfattelsen af, at læringen foregår som en vekselvirkning mellem den indre (allerede eksisterende viden) og de ydre påvirkninger i form af nye indtryk og informationer (ny viden) som tilføres, hvilket blev beskrevet af den schweiziske psykolog Jean Piaget (1896-1980) som konstruktivismen.

Kontruktivisme

Den indlæringsteoretiske grundantagelse for den gode måde at vejlede på er konstruktivismen[1]. Konstruktivismens kerne er at viden konstrueres hos det enkelte individ som en vekselvirkning mellem eksisterende viden og omgivelsernes inputs, hvilket også betegnes som en stadig vekslen mellem assimilations[2] - og akkomodationsprocesser[3], som blot faciliteres af læringsrummet. Dvs. den lærende er i centrum og underviseren har til opgave at planlægge og fastsætte rammerne for at den enkelte studerende indgår i de mest optimale rammer for indlæringen af et pensum (en konstruktion der typisk er beskrevet i Den Didaktiske Trekant). Derfor mener jeg, at undervisningen i TEORI søjlen nødvendigvis må være planlagt og struktureret og gøres eksplicit for den studerende – dog med visse 'gemte' læringsøvelser, som kan betegnes implicitte. Men selve læringen sker udelukkende ved studentens egen aktivitet og er eksplicificeret.

Undervisningspædagogik og studentervejledning på universitet

Grundlæggende er formålet med universitetsstudiet at opnå dyb læring og analytisk evne indenfor et fagligt felt med de metoder, der hersker her. I løbet af 1980'erne, hvor masseuniversiteterne skød op og hvor flere skulle læres op til 'lærde' (hvilket jo i høj grad er aktuelt i disse år) blev det undervisernes vigtigste opgave er at tilrettelægge undervisningen, således at så mange studerende som muligt kunne opnå denne dybe teoretiske læring. Dette afstedkom forskning i undervisning og læring på universitetsniveau og med konstruktivismen kom de studerendes aktiviteter i undervisningen i centrum (Rienecker et al. 2013, s. 97). Begrebet *Contructive Alignment*,

[1] I overensstemmelse med eksempelvis Learning Styles Lab på Handelshøjskolen, AU (referenceeksempel "Hjernen er ikke en krukke der skal fyldes op, men en ild der skal tændes". Om vejledning og vejledningskurser. Af lektor Karen M. Lauridsen, lektor samme sted).

[2] Assimilationsproces: Tilpasning til noget allerede eksisterende.

[3] Akkomodationsproces: Læring for at tilpasse sig et ude fra kommende stimulus.

CA, (Biggs & Tang 2007) blev defineret og indeholder ideen om, at eksamen skal planlægges således, at de studerende testes på en måde og i et pensum, der henholder sig til akademias krav og derfor styrer dem i den 'rigtige' retning. Karaktererne skal derfor fortælle om den studerendes akademiske evner og faglige viden. CA-modellen lægger således mål, prøveformer, bedømmelseskriterier og læringsaktiviteter frem, hvilket danner et solidt grundlag og et didaktisk redskab til planlægningen af undervisningen – i relation med denne opgave, vejledningen (Rienecker et al. 2013, s. 99).

Forventningsafstemning

Selvom det måske kan virke selvmodsigende, beretter litteraturen om at nogle studerende har modvilje mod vejledning (Rienecker et al. 2005, s. 56f). I så tilfælde vil det være yderst informativt for vejlederen, at kende til dette inden forløbet går i gang – og en samtale om indstillingen til vejledning og opgaveforløbet kan for nogle studerende ændre på den opfattelse, hvis det f.eks. skyldes tidligere dårlige oplevelse. Ligeledes kan vejlederen have faglige rutiner, obligatoriske krav fra universitets side eller fra fagområdets side, som ikke er til diskussion i forbindelse med forløbet – og dette kan den studerende have gavn af at vide på forhånd. Vejleder er i vejledningssituationen dels er akademia-institutionens repræsentant og skal dels sikre at al forskningsaktivitet gennemføres i overensstemmelse med alle etiske og forskningsmæssige praksisser (Rienecker et al. 2005, s. 23ff). Derfor er det for alle parter en fordel at tage en snak om hinandens forventninger til forløbet, hinanden og sig selv inden forløbet går i gang. Med fokus på vejlederen foreslås det at gøre brug af et *vejlederbrev/-kontrakt*, hvori alle mere generelle krav, forhold og rutiner o.lign. kan nedskrives og dermed afklares fra starten (Rienecker et al. 2005, 2013, s. 60ff, s. 329ff).

Opgaveafgrænsning

Denne opgave har to foci i forbindelse med vejledningssituationen: 1) Inklusion af den studerende i et vejledningsforløb og 2) en 'constructively aligned' vejledning frem mod eksamensprodukterne: Et skriftligt materiale og et oralt forsvar. AD.1: En forventningsafstemmende inklusion af den studerende ind i den akademiske verden på vejlederens hold, hvor begge parter kender samarbejdets spilleregler. AD.2: Ifølge John Biggs' CA-tanke skal vejledningen under udfærdigelsen af et bachelor/kandidatspeciale i TEORI søjlen lede frem mod en skriftlig fremstilling af et videnskabeligt arbejde (eller problemstilling) og træning i at præsentere og diskutere resultaterne i en forståelig kontekst og diskutere videnskab på et fagligt niveau. Efter min mening skal vejledningen i den forbindelse fokusere på øvelser i 1) at planlægge og styre arbejdsprocessen til udfærdigelse af opgaven, 2) at forstå litteraturen korrekt (opøve kritisk sans af denne via diskussion), 3) at skrive videnskabeligt og koncist, 4) at præsentere og diskutere faget oralt.

Problemformulering

Det Ansvarsfulde Vejledningsforløb

Fokus 1: Inklusion af studerende. Udarbejdelse og evaluering af Logbog for trinvis inklusion af den studerende hos vejlederen. Trinene skal tage hensyn til de behov den studerendes har for at kende spillereglerne og kravene og de behov vejlederen har for at kende den studerendes tanker omkring opgaveskrivningen (forventninger, ambitionsniveau, krav, indsats, o.lign.).

Fokus 2: Constructive Alignment-vejledning frem mod specialeopgave og mundtligt forsvar. Opstille vejledningstrinnene af studerende frem mod dennes udarbejdelse af den skriftlige opgave og orale forsvar af denne ud fra John Biggs' Constructive Alignment-teori.

Resultater & Diskussion

Fokus 1: Logbog for inklusion

Første del af opgaven går på at undersøge og afdække forventningerne til vejledningen i opgaveskrivning dels hos et hold bachelorstuderende på medicin med et interaktivt spørgeskema (Shakespeak) og dels hos min kandidatstuderende fra human fysiologi, som startede hos mig august 2014 via et semi-struktureret recall-interview.

Resultat af spørgeskemaundersøgelsen blandt bachelorstuderende på medicin

67 bachelor medicin studerende besvarende spørgsmålene. 2/3 skriver litteraturopgave på egen hånd. 1/10 skriver empiriopgave og har taget et

semester helt eller delvist studiefri. Kun 6% søger eksternt for at opleve forskningen væk fra universitet (Panum). Det er reelt set således kun disse 6% (7 studerende), som er den helt rigtige målgruppe. Men svarene fra alle studerende bliver brugt som grundlag for spørgeskemaundersøgelsens konklusioner. Mere end halvdelen går efter at finde en vejleder, der er ekspert i opgaveemnet mens cirka 1/3 blot skal finde en tilfældig vejleder, som vil være interesseret i at vejlede dem. Sammenlignet med den videnskabelige litteratur om vejlederrollen samt spørgeskemaundersøgelsen blandt specialestuderende på humaniore og samfundsvidenskab (Harboe, 2000) (Rienecker et al. 2005, s. 52f) finder jeg, at medicinstuderende i højere grad går efter en faglig stærk vejleder (>50% mod 20-25% hos kandidatstuderende, som må forventes at stille højere faglige krav til vejleder end bachelorstuderende). Til gengæld går mere end 90% efter en vejleder, som enten er sød og rar eller som i det mindste tager sig tid til at tale med den studerende. Denne opfattelse bør tages til efterretning blandt vejledere, som måske ofte vil være tilbøjelige til at fokusere på det faglige (Rienecker et al. 2005, s. 54f). Det er således også bemærkelsesværdigt, at >50% mener, at vejlederen bør bruge den nødvendige tid (mere end normeret) på vejledningen mens 40% forventer at vejleder henholder sig kursusbeskrivelsens vejledningstid. Det er interessant at så mange medicinstuderende har en forventning om, at de vil modtage den nødvendige vejledning – også selvom det ligger ud over normeringen.

Til gengæld er det ligeledes bemærkelsesværdigt, at opfattelsen om hvis ansvar det er at indkalde til selve vejledningen deler sig 50:50 mellem at vejleder enten delvist har planlagt vejledningsforløbet eller kun udøver vejleder på den studerendes opfordring.

90% forventer at vejleder underviser i opgaveformulering og 75% forventer at vejleder underviser i disposition. Dette er helt i tråd med hvad der er vejlederens primære opgaver ('pentagonen' (Rienecker et al. 2005, s. 45)) men noget mere end undersøgelsen blandt humaniore og samfundsfagsstuderende (Harboe, 2000) (Rienecker et al. 2005, s. 52). Næsten 90% forventer at modtage hjælp og sparring til at søge, læse, forstå og diskutere videnskabelig litteratur og næsten 75% forventer at vejleder kommenterer den endelige opgave.

Næsten alle (>95%) ønsker at få afklaret mange af ovenstående spørgsmål inden selve vejledningsforløbet går i gang og 2/3 mener at det er deres eget ansvar at indkalde til et sådant møde (og altså ikke vejleders) og vil selv indkalde til mødet, hvis vejleder ikke tager initiativet. Dvs. op mod 1/3 af de studerende vil ikke selv indkalde til et sådant afklarende møde, som derfor ikke bliver afholdt, hvis vejlederen ikke påtager sig dette ansvar!

Mere en 50% sætter lighedstegn mellem mængden af vejledning og god karakter for opgaven. Dette understreger vigtigheden af, at den studerendes ambitioner eksplicifiseres helt fra start og at det gøres klart at karakteren ikke er en bestillingsvare (Rienecker et al. 2005, s. 53f). Det kan ligeledes være en fordel for vejleder at vide, hvilket ambitionsniveau den studerende har til karakteren. Dette kan der refereres tilbage til undervejs i forløbet, hvis vejlederes vurderer, at arbejdsindsatsen eller niveauet lever op til et anderledes karakterniveau (Rienecker et al. 2005, s. 43).

I relation til CA-teorien er der overraskende få studerende, som forventer reel undervisning/vejledning i dét, de skal eksamineres i: Kun 50% forventer at vejleder underviser i videnskabelig skrivning og 1/3 forventer at få øvelse i og feedback på at præsentere videnskabeligt. Min vurdering er at det er en erfaringsbaseret holdning. Fordi nogle har hørt om manglen på direkte undervisning under vejledningsperioden, nedjusterer mange deres forventning til at modtage direkte undervisning, som kan siges at danne CA med deres eksamensprodukter. Dette forhold understeger blot vigtigheden af at få sat fokus på CA i vejledningssituationen og dermed relevansen af denne opgave.

Opsamling på spørgeskemaundersøgelse blandt bachelorstuderende på medicin

- Næsten alle går efter en sød og rar vejleder som tager sig tid (mange mener også mere tid end normeringen foreskriver) til den studerende og halvdelen går også efter en faglig stærk vejleder.

- Næsten alle forventer at blive vejledt i opgaveskrivningen (opgaveformulering og den videnskabelige disposition) samt i læsning, tolkning og diskussion af videnskabeligt litteratur.

- Mere en 50% sætter lighedstegn mellem mængden af vejledning og en god karakter.

- 75% forventer at vejleder læser og kommenterer den endelige opgave igennem inden aflevering.

- Der er ikke udbredt forventning til at det er vejlederen der indkalder til vejledermøder.

Resultat af semi-struktureret recall-interview af kandidatstuderende

Han havde lave forventninger til vejledningen på baggrund af andres erfaringer. Forventede at være meget på egen hånd. Har nu (efter ca 6 mdr) indset at han kunne have haft gavn af en struktureret samtale om forventninger, krav, ambitionsniveau, m.m. Denne samtale skulle helst ligge, når man har haft mulighed til at snuse lidt til afdelingen/gruppen. Men pga. de lave forventninger, som han kom med, efterspurgte han det ikke. Kunne også godt have tænkt sig at kende til mine forventninger og arbejdsmåder. Det er dog kommet hen ad vejen, men for en anden studerende kunne det have været frustrerende ikke at kende til dette.

Senere hen i forløbet har han følt sig godt vejledt. Men har ikke opfattet det som vejledning – men mere som gode kollegiale snakke og udveksling af ideer om arbejdsmåder.

Har nu (efter ca 6 mdr) indset at han godt kunne have brugt at blive mere vejledt i starten, om hvordan projektarbejdet og opgaven skulle opstartes/udformes. Følte sig lidt alene med sit eget projekt. Blev koblet på som medarbejder på et andet projekt for at inkludere. Det virkede meget motiverende og afhjalp ensomheden (men hjalp ikke på overblikket af egen opgave).

Overblikket over specialeprojektet formede sig efter at have fået til opgave at konkretisere sit projekt i en oral fremlæggelse på et gruppemøde (efter 1½ måned). I denne forbindelse fik han direkte vejledning/sparring til at definere sin opgave. Det var en god, konstruktiv og lærerig proces.

Logbog: Tidskronologi og samtaler ved inklusion

Tre inkluderende møder: Inklusionen sikres via 3 planlagte samtaler, som trinvist inkluderer den studerende for vejleder og arbejdspladsen og har til formål at sikre etableringen af en god og respektfuld samarbejdsrelation (Rienecker et al. 2013, s. 330f). Selvom min spørgeskemaundersøgelse viste, at størstedelen af de studerende vil kontakte vejlederen og bede om en samtale til at afdække sådanne praktiske forhold er det stadig 25-33%, som ikke vil – heriblandt min kandidatstuderende, som jo indser retrospektivt, at samtalerne ville have været passende at have haft. Endvidere kan det ikke sikres at alle overvejelser udveksles med alle studerende, hvis samtaler sker på de studerendes opfordring. Ved at strukturere og planlægge det inkluderende forløb ret detaljeret sikres det, at alle studerende får de (ifølge teorien og deres medstuderendes) nødvendige oplysninger, som kun vil være en fordel for det efterfølgende samarbejde med vejleder.

MØDE#1 er første møde mellem studerende og vejleder. Formålet er at hilse på hinanden og lytte til den studerendes forhåndsforventninger og ambitionsniveau. Der høres til uddannelsesmæssige og jobmæssige planer samt tidsmæssigt involvering i projektet og øvrige interesser. Disse informationer kan vejleder senere bruge, hvis der skulle opstå uoverensstemmelse mellem arbejdsindsats og ambitionsniveau.

MØDE#2 er 'kontrakt'-mødet, som jeg har valgt at lægge ud som en samtale og ikke udlevere på skrift (brev/kontrakt) (Rienecker et al. 2013, 2005, s. 332ff, s. 51ff). Her skal den studerende få en fornemmelse af sit eget ansvar for at drive processen og være tovholder for sit eget projekt. Den studerende får til opgave at indkalde til vejledermøderne med et skriftligt oplæg og skrive et referat efterfølgende med det formål at forbedre evnen til essenudtræk, præcision, nøjagtighed og beslutsomhed/gennemslagskraft samt at sikre CA for opgaveudarbejdelsen og akademisk arbejde efterfølgende. Endvidere skal den studerende præsentere en tidsplan for at opøve arbejdstidsplanlægning, som jeg mener, er en stor del af 'skrivebordsarbejdet' som forsker. Teksten bliver således gjort til genstand for middel til og for evaluering (Rienecker et al. 2005, s. 77ff). F.eks. viser min undersøgelse, at mange studerende forventer, at den endelige opgave læses og kommenteres af vejlederen. Dette er jeg absolut ikke enig i, da det jo skal være den studerendes eget produkt der bedømmes til eksamen. Derfor gøres dette forhold klart og eksplicit i begyndelsen (MØDE#2). Dog foreligger der mulighed for at få kommenteret tekstdele af opgaven helt frem til at den studerende begynder at samle alle delafsnittene og udfærdige den endelige opgave (Måned 'sidste' i Tidskronologien). Under MØDE#2 understreges det ligeledes, at meget vejledning ikke i sig selv medfører en god karakter.

MØDE#3 er det praktiske opstartsmøde, hvor den studerende fysisk starter sit ophold på afdelingen. Her er det blot vigtigt at den studerende føler sig velkommen og taget seriøst og integreres på afdelingen som medarbejder.

14.0.1 Fokus 2: Logbog for CA til opgaven og forsvaret

Målet med anden del er ud fra John Biggs' CA-teori at tilrettelægge et vejledningsforløb for bachelor- og kandidatstuderende, der er indskrevet på natur- eller sundhedsvidenskab. Inden opstarten af vejledningsforløbet med de tre bachelorstuderende havde jeg med baggrund i teorien udarbejdet en Logbog i henhold til John Biggs' CA-teori. Efter endt ophold hos mig (juni 2015) gennemførte jeg et semi-struktureret interview af de tre bachelorstuderende, om hvordan de synes vejledning havde været. På baggrund heraf evaluerer (diskuterer) jeg overvejelserne i logbogen og foretager nødvendige justeringer.

Udkast til logbog

Selve vejledningen: Selve vejledningen: MØDE#4: I overensstemmelse med teorien er vejledningen i de tidlige faser af projektarbejdet vigtigst. Der skal lægges meget energi tidligt hvor vejledningen skal rette sig mod overordnede og generelle forhold, som kan være pejlemærker for resten af opgaven og kriterier for at tage stilling til mindre problemer og detaljer (Rienecker et al. 2005, s. 73f). Derfor er der efter de inkluderende samtaler og opstarten indlagt MØDE#4, som tidligt i forløbet har til formål at få den studerende til at konkretisere sin opgave og arbejde med tidsstyring. Cirka 1-2 uger senere afholdes MØDE#4-2, hvor den studerende 'tvinges' til at præsentere sit projekt i abstrakt-format og oralt foran flere kollegaer. Allerede her søges CA i forhold til eksaminationen og den studerende bliver kastet ud foran kollegaer, som de stadig kun lige har mødt og de får direkte kritik og feedback på deres præstation. Hvis kollegaerne ikke forstår det korrekt må det være forklaret uklart! Min erfaring er, at de studerende er meget spørgende til, hvad de egentlig skal og hvordan. Hvad jeg vil have? Men den studerendes selvstændighed (eller tro på sine egne akademiske evner) skal netop vækkes her – de skal selv komme op med deres ide og deres version af en plan til at tilgå videnskaben (Rienecker et al. 2005, s. 137ff). Det forklares for dem at læringen mest ligger i processen frem til MØDE#4-2 og ikke på selve dagen! Det endelige mål med opgaven er jo netop at vurdere og karaktergive den studerende for sine akademiske evner, som kun kan vises med en tro på egne evner og en vis grad af selvstændighed. Samtidig lader jeg den studerende vide, at min dør altid er åben. At de kan komme til mig med deres tanker inden de bliver til frustrationer. Dermed påtager jeg mig coachrollen om at kunne begå sig i miljøet i form at mønster- og kulturvejleder i forskningsverdenens til tider egoistiske og karriereorienterede verden (Rienecker et al. 2005, s. 159ff). Det bunder i, at jeg ønsker at den studerende med sit ophold eksternt i forskningsverdenen skal blive klogere på, om de egner sig til en akademisk karriere. De skal have en reel fornemmelse af miljøet og arbejdsvilkårene og skal derfor også tilbydes at få sparring til at behandle deres oplevelser og mere personlige stridigheder, der må dukke op (Rienecker et al. 2005, s. 185ff). Efter de to første vejledningsmøder, som ligger tidligt i forløbet er der planlagt ét månedligt vejledningsmøde (Vejledningsmøde#n+1 i Tidskronologien) for at sikre et minimum af kommunikation med den studerende. Men det forventes, at der vil forgå en ad hoc-vejledning flere gange ugentligt i en mere kollegial relation, om både emner indenfor PRAKTIK og TEORI søjlerne.

Journal Club: Journal Clubs (JC) skal opøve den studerende i at læse, forstå, diskutere og forholde sig kritisk til resultater på baggrund af anvendte undersøgelsesmetoder og design samt konklusionerne. JC afholdes med deltagere fra hele forskningsgruppen og er ikke et tiltag, der udelukkende er til de studerende – men for alle!

Evaluering: En evaluering af selve projektforløbet indeholdende både den PRAKTISKE og TEORETISKE søjle i Figur 14.1.

Evaluering af udkastet til Logbog

De første Vejledningsmøder: De bachelorstuderende var enige om at opgaven var difus og svær at definere i starten for dem. Dette understreger vigtigheden af at sætte fokus på vejledningen i før-skrivnings- og begyndelsesperioden (Rienecker et al. 2005, s. 69ff). Derfor er MØDE#4 og MØDE#4-2 helt afgørende og de evalueres godt af de studerende. Møderne satte gang i tankerne og opgaven tog form i den proces. Én mente at det lå lidt tidligt andre lidt sent. Denne forskel tror jeg er et udtryk for, i hvilket omfang den enkelte studerende har tænkt over sit projekt inden opstart. Min konklusion er derfor, at det bedst løses ved at melde ud i god tid at møderne kommer og tidligt at have tiltag, der får de studerende i gang med processen. Løsning; at placere MØDE#4 lidt tidligere for at sætte gang i tankerne hos den studerende og derefter tillade cirka 3 uger op til MØDE#4-2 for at give tid til at konkretisere projektet (4-Vejledningsmøde og 4-2-Vejledningsmøde i Tidskronologien).

Mængde af vejledning: Fordelingen af vejledningsmøder og ad-hoc vejledning blev evalueret tilfredsstillende. Specielt var de glade for min altid åbne dør, at de til enhver tid kunne kigge ind, hvis de havde noget på hjertet. Dog var de alle lidt tilbageholdende med at bruge mig undervejs efter de første to møder (MØDE#4 og MØDE#4-2) bl.a. til at rette deres skriv. De udtalte, at jeg jo også havde meget at se til og at de ikke ville belemre mig med deres opgaver. Dette på trods af at jeg synes at have kommunikeret at de altid var velkomne. Men deres enighed må føre til en ændring af min praksis. Derfor har jeg indføjet i MØDE#2, at vejledningsmøderne (efter MØDE#4-2) skal fastsættes fremadrettet i samråd mellem den studerende og mig – og helst fra gang-til-gang. Det er stadig den studerendes opgave forud for mødet at fremsende materiale og beskrive mødets emne.

Mere vejledning? De vurderede alle, at de i løbet af projektperioden var blevet bedre til at skrive videnskabeligt, bedre i stand til at præsentere deres projekt mundtligt og diskutere resultaterne kritisk og følte sig således godt trænet under deres ophold hos mig til eksaminationen. Aktiviteterne der førte til denne progression og læring mente de studerende var MØDE#4 og MØDE#4-2, ad-hoc vejledningen og Jorunal Clubs. Med det formål at finde ud af om mine tre studerende ville tage imod endnu mere vejledning spurgte jeg om, hvad deres kommentar var til en intens vejledningsproces den sidste måned op til afleveringen. Hertil svarede alle, at de ikke syntes det var nødvendigt og blot ville være en stressende faktor der ville presse dem til at levere 'overflødige' tekster så tæt på den endelige opgave. Samtidig understregede de også alle, at de havde lagt en stor arbejdsindsats i PRAKTIK delen (Figur 14.1) og at arbejdspresset var højt op imod afleveringen af opgaven. Alt i alt var de studerende således ikke bare interesseret i så meget vejledning som muligt. Den planlagte vejledning skal derfor være veltilrettelagt og begrundet med nogle egentlige mål for den enkelte vejledningssession. F.eks. vil Vejledningsmøderne#n+1 (Tidskronologien) have dels et tekst-specifikt fokus [ufærdige afsnit til introduktion, metode eller diskussion (Rienecker et al. 2005, s. 103ff), hvilket vælges af den studerende – evt. i samråd med vejleder] (Rienecker et al. 2005, s. 89f). Oftest vil jeg tillige vælge også at have fokus på resultatafsnittet, enten som helhed eller på et specifikt resultat fra den studerendes projekt. Hvordan tager det form og hvordan den studerende forestiller sig det skal præsenteres i opgaven. Dette vil holde dem fokuseret på resultatbehandling og analyse samtidig med skriveprocessen. Ad hoc-samtalerne ligger ud over de planlagte vejledningsmøder og er meget brugte af de fleste studerende, som roser dem. Disse samtaler opfanger de mere individuelle behov, som studerende har for at få bekræftet, afprøvet, tjekket et eller andet de lige sidder med. Nogle har ikke det behov og her holdes vejledningen fortrinsvis til Vejledningsmøderne#n+1 (Tidskronologien).

Feed-back på delopgaver: Selve feed-backen på et skriftligt materiale kan foretages på flere måder – nok valgt fortrinsvis efter vejleders præference (Rienecker et al. 2005, s. 77ff). Jeg foretrækker at aflevere feedback mundtligt med baggrund i kommentarer i teksten – ikke som et samlet skriv og heller ikke uden en mundtlig opfølgning. Det materiale den studerende fremsender inden vejledningsmødet indeholder teksten, der skal diskuteres samt et 'følgebrev' (oftest blot teksten i en mail), som kort beskriver, hvilket fokus der ønskes ved vejledningsmødet (Rienecker et al. 2005, s. 105). Mine erfaringer fra faglig og pædagogisk supervision i forbindelse med et af mine vejledningsmøder er, at den studerende ved mødet bør starte med at præsentere sit materiale hvorefter dialogen/vejledningen går i gang. For mine bachelorstuderende var jeg ikke skarp nok på kravet om, at de studerende skulle fremsende et referat af hvert vejledningsmøde. Men det anbefales i litteraturen og jeg er selv overbevist om, at en sådan refleksion hos den studerende vil addere til læringen og udbyttet fra vejledningsmødet. Derfor skal den studerende afslutningsvis på mødet mundtligt summere op, hvad han/hun konkret fik med fra vejledningsmødet og mindes om at fremsende referatet senest dagen efter (jf. MØDE#2).

Tidsstyring: Tidsplanen (jf. MØDE#2) tages op sidst i hvert vejledningsmøde i sammenhæng med at planen for den kommende periode lægges. Den studerende spørges om, hvad der i tidsplanen retrospektivt holdte og hvad der ikke virkede og hvorfor, samt at komme med forslag til arbejdsfokus i den kommende periode. Denne prospektive tidsplan vedlægges referatet. Jeg mener at tidsstyring og administrering af egen arbejdstid er en stor del af det daglige arbejde i akademia. Vi har så mange opgaver vi kan tage os af og derfor er overblik og prioriteret valg af arbejdsopgaverne vigtig for at alle opgaver løses og at de akutte bliver sendt videre i rette tid.

Journal Clubs: Selvom artiklerne i JC'erne ikke alle var relevante for de studerendes opgaver, synes alle at det var en god proces og meget lærerigt at alle forskningsgruppens forskere (også de mere seniore) deltog. Min konklusion ud fra deres evaluering er, at JC trænede dem i at læse, forstå og diskutere videnskabelig litteratur på en meget mere brugbar måde end studiets læsegrupper og gruppeundervisning har tilbudt. Endvidere kom det frem fra to studerende, at de syntes at de var blevet mere sikre på deres holdninger til den litteratur, som du havde brugt til opgaven og deres egne metoder og konklusioner. Dermed kan JC understøtte den studerendes videnskabelige kritiske sans og evnen til at skille godt og skidt fra hinanden – og dermed forbedre deres selvstændighed. En evne som de vurderede, at de havde haft gavn af ved det mundtlige forsvar.

Præsentationsøvelse: Én af de tre studerende nævnte at der i løbet af en 3 måneders projektperiode godt kunne ligge en øvelse af præsentationsteknik igen hen mod slutningen, hvor det blev mere aktuelt mht. eksamen. Denne gentagne træning af præsentation havde jeg (forsøgsvis) lagt ind hos en anden af de tre studerende. I forbindelse med arbejdet i PRAKTIK søjlen, skulle han forklare dele af sin opgave for en anden medarbejder. Således ikke med henblik på selve fremlæggelsen eller hans projekt, men med det formål at diskutere metoden til at analysere data. Dvs. fokus var flyttet fra selve præsentationen hen på indholdet og den videnskabelige kommunikation. Der var således direkte respons på hvor klart der blev kommunikeret og hvor god præsentationen var. Feedbacken fra den studerende på denne 'øvelse' var, at det virkelig var godt og at han havde arbejdet grundigt med denne præsentation for at få den så klar som mulig. Denne erfaring brugte han i høj grad til præsentationen af sin opgave til eksamen. Denne form for øvelse mener jeg virkede godt og er en god måde at træne studerende i præsentation – at kaste dem ud i en mere arbejdsmæssig opgave, hvor de får øvet den mundtlige præsentation og diskussionsevne i en mere 'virkelig' sammenhæng. Det er en implicit CA læring: De studerende får en virkelig opgave i akademia, som de skal løse (jeg vil formode at nogle sågar vil synes, at det kan være en lidt urimelig opgave) men som samtidig træner dem i eksaminationen. Dog tror jeg, at det kan være en fordel efterfølgende at eksplicificere CA-delen overfor den studerende for at få dem til at reflektere over øvelsen og erkende overførbarheden og opnå endnu mere læring.

Slutevaluering: For at sikre den mest nøgterne og ærlige evaluering fra begge parter bør evaluering lægges *efter afleveringen* men *inden karaktergivningen* (Evaluering efter aflevering i Tidskronologien). Udover den planlagte evaluering af projektforløbet og vejledningen bør vejleder også evaluere den endelige opgave. Dette giver vejlederen mulighed for at give en forhåndsvurdering af opgaven og dermed den studerende en realistisk fornemmelse af hvor opgaven ligger karaktermæssigt. Således kan skuffelsen over en dårligere karakter end forventet mindskes – og klager undgås (Rienecker et al. 2005, s. 75f).

Konklusion

En planlagt og progressiv inklusion af en studerende på en forskningsinstitution forud for et vejledningsforløb er et centralt fundament for et konstruktivt samarbejde med vejlederen. Litteraturen og de fleste studerende er enige om at afklaringen af forventninger, ambitionsniveauer og arbejdsmåder og –indsats er vigtige områder at få klarlagt i initielle samtaler. Dette bakkes tillige retrospektivt op af en kandidatstuderende som imidlertid ikke bemærkede det i situationen. Tidsfastsatte møder og skriftlige leverancer til vejledninger gennem hele forløbet samt en tidlig opgave- og emneafklaring indeholdende en skriftlig og mundtlig præsentation af ens projektideer får den studerende gjort tryg ved stedet og processen. Herefter vil der være mere overskud til at kaste sig over praktiske overgaver i forbindelse med forskningen på afdelingen. Når den praktiske del så er kommet godt i gang er det vigtigt at fastholde den studerende i sin opgaveskrivning ved fælles planlagte møder med en klar progression relateret til opgaven. Den åbne dør til vejleder er et vellidt gode for alle studerende og synes erfaringsmæssigt ikke at blive misbrugt og ligeledes trænes den studerende i kritisk læsning af videnskabelig litteratur generelt ved at deltage i fælles journal clubs. En sådan inklusion i afdelingen blandt ældre forskere og f.eks. ph.d.-studerende er meget lærerigt og motiverende for de yngre studerende. Den studerende skal fastholdes i at fortsætte det teoretiske arbejde ved siden af det praktiske under hele forløbet. Måske ikke altid med en 1:1 tidsfordeling. Slutteligt bør der evalueres med den studerende: både projektforløb og den skriftlige opgave.

Perspektivering & Begrænsninger

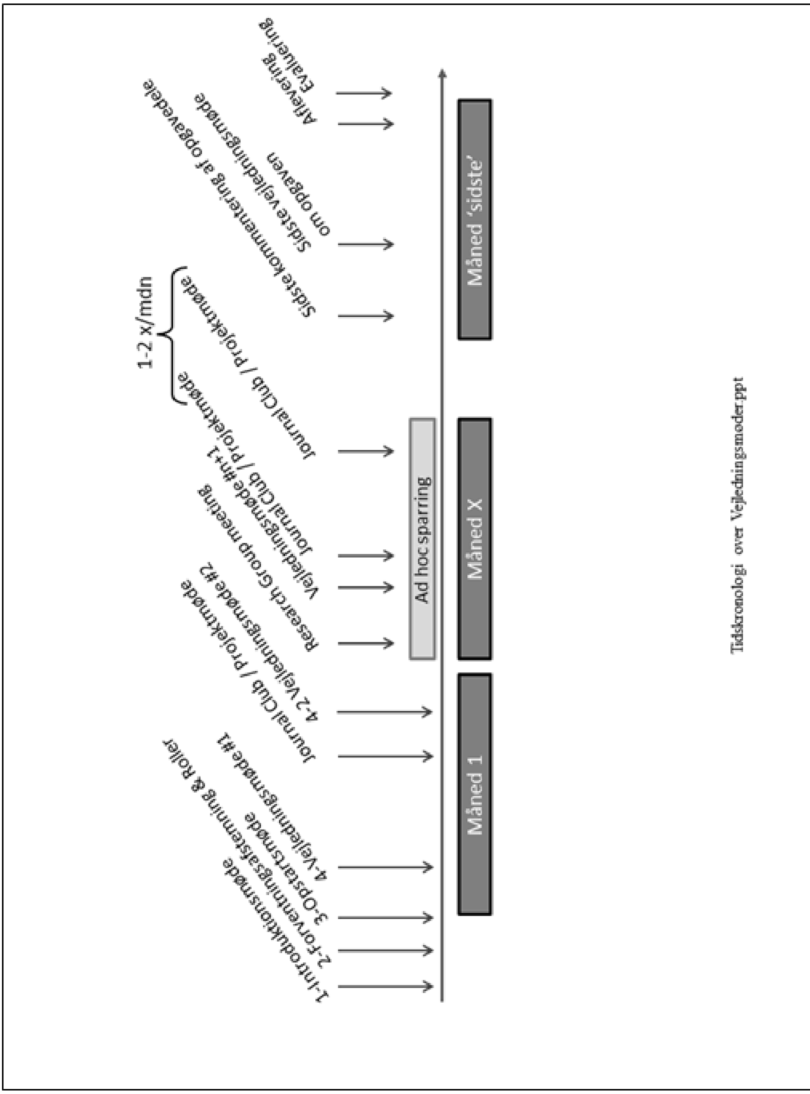
Mit primære budskab efter udarbejdelsen af opgaven **Det Ansvarsfulde Vejledningsforløb** er, at det meste af den refleksion, som jeg har været igennem og de erfaringer og konklusioner som jeg har gjort ***NEMT*** og ***BØR*** gøres ved

1. at have en plan for sit vejledningsforløb,
2. evaluere forløbet med de studerende og
3. og lave justeringer og kommentarer til individuelle behov og personligheder.

Det kræver ikke en dyb pædagogisk viden at implementere disse rutiner men mere en ansvarsfuld indstilling til det ansvar der ligger i at være vejleder for bachelor- og kandidatstuderende.

Som det kan læses af opgaven er alle studerende ikke ens og jo flere studerende man har igennem og får talt med om forløbet, jo mere erfaring får man som vejleder og jo mere vil ens faglige 'empati' udvikles. Begrænsningen i opgaven er derfor det lille antal evalueringer. Men hvis både evalueringsspørgsmålene og evalueringsresultaterne for hver ny studerende indbygges i skabelonen for vejledningen, så vil den kunne forbedres og justeres til at tage højde for forskellige personligheder og behov blandt studerende.

A Bilag



Tidskronologi over Vejledningsmøder.ppt

15

Improving students' learning through study tour

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Introduction

> *Teach me and I will forget; Show me and I may remember; involve me and I will understand. – Benjamin Franklin*

Evidences from teaching practice and research show that a student's attention starts to reduce after twenty to thirty minutes in a traditional lecture (Krakowka 2012, Bligh 1998). To provide effective learning environment, lectures can be combined with other teaching forms such as discussions, simulations, and fieldwork. Fieldtrip (or excursion, study tour) is considered an important way of encouraging deep learning, because students gain much out of seeing and experiencing things in person (Krakowka 2012).

In Urban Water Management course that I teach, study trip is one of the key components. However, much effort has been paid to practical things in earlier years' trips. I felt that it should be improved by more relating its contents to the lectures, and by promoting active learning and reflection during and after the trip. This was then chosen as the theme of the UP project. It is hoped that the project can provide evidence on what we can do for this and whether the improved study trips do contribute to the learning effect and the appreciation for the course. Experiences can be applied for study tours in other courses in the future.

The report first introduces the course used for this project and its study tours. Then related theories and actions done for improving the study tours are presented. Further on, the report presents the results of these actions, by looking at the results of the pre- and post-trip questionnaires, the final course evaluation, the written exam, and by observation during the trips. The report finally analyzes and discusses the results.

The course and the study tour

The Urban Water Management course is within a two-years' master program 'Water and Environment' at the SDC (Sino-Danish Center for Education and Research) – a collaboration between University of China Academy of Science and the Danish Universities. It is taught in Beijing with both Chinese and Danish teachers and students. In 2015 the course runs for three weeks full-time. The 18 students come from various environmental disciplines during their bachelors. It aims at providing students sufficient knowledge on central issues relating to urban water systems and their challenges, so that they can apply their earlier knowledge to 'help the city to solve its water-related environmental problems'.

The course is based on lectures, in-class exercises, guest lecturers and study tours. Teaching is structured in two parts. The first part is mainly about knowledge building. The second part seeks to strengthen innovation skills with group assignment to provide an innovative solution with nature-based approach to an urban water challenge. Grading is based equally on a group assignment and a written exam. I am responsible for the study tours, a couple of lectures/in-class exercises, and course coordination. The overall course responsible and key lecturer, Professor Marina Bergen Jensen, supported with ideas and comments. The course had three study tours: two half-day's tours in Beijing right after morning lectures in the first part, and a two-days' trip to Tianjin Eco-city and TEDA in the start of the second part. Study trips are decided not to require written assignment, in order to balance the students' working load. Though attention has been put to all three study trips, the third study tour received more effort, because of its complexity and available time and resources. The objective of the study trip to Tianjin was to experience real eco-technology examples, with emphasis on water treatment and environmental technology. It is hoped that the students can link these examples with the taught theories and apply the theoretical knowledge for innovation.

Development of the course study tours for effective learning

Many scholars see the value of fieldtrips for learning because its role on consciousness-raising. Students are motivated to learn, since they receive challenges relating to them, and are urged to respond to those challenges (Freire 1970). They believe that education should 'involve the articulation of experience, critical thinking and reflection and action' (Jakubowski 2003). Others emphasize the role of fieldtrips for improving learning by doing. Referring to Kolb's theory that 'learning is the process whereby knowledge is created through the transformation of experience' (Kolb 1984). Krakowka (2012) saw the great potential of fieldtrips for the students to gain concrete experiences leading to the greatest degree of learning. He adapted Kolb's experiential learning cycle for fieldtrip and identified the main stages (Table 15.1). Wong & Wong (2009) conceptualized a three-

Table 15.1. Kolb's experiential learning cycle adapted for fieldtrips (Krakowka 2012)

Kolb's learning stages	Examples for fieldtrips
Active Experimentation PLAN	Looking at maps, researching the area of the fieldtrip, planning a route
Concrete Experience DO	The fieldtrip
Reflective Observation OBSERVE	Reflecting on the fieldtrip and what was discovered
Abstract Conceptualization THINK	Using what was experienced in a geographical framework Applying what was experienced to learned concepts

stages learning - research, experience, and capture - for how a fieldtrip can enhance student learning. 'Phase 1, the pre-trip phase, requires careful planning from the teacher and research by the students. During Phase 2, the on-trip phase, it is important for the teacher to take individual care of the students and for the students to keenly participate in all activities. Phase 3, the post-trip phase, requires the teacher to help students reflect on what they have learned from the class and from their experiences during the fieldtrip.' Mcloughlin (2004) then suggested some practical guide for developing a learning-effective fieldtrip (Table 15.2): These earlier theories and experiences are applied for the development of the study tours. Specific actions for the development of the study tours in Urban Water Management 2015 are presented in Table 315.3.

Table 15.2. Suggestions for developing a learning-effective fieldtrip (adapted from Mcloughlin (2004))

Teacher's action	The purpose
Plan interesting activities before, during, and after the trip	To encourage students to hypothesize, compare, analyze, synthesize, create, and reflect on their experience
Allow students' input into what trips they might like to take	Ownership increases engagement
Emphasize the trip's significance and learning objectives prior to the trip	To tie the trip to the curriculum
Incorporating student projects into a trip	To facilitate learning
Encourage verbal narratives about learned information, or sketches, photo essays, etc.	To intensify the meaning got from the trip experience
Discuss what they learned and discovered and share this with their peers	To make students to repackage and synthesize important content-related learning, reconstruct, reinforce, and to develop deeper understanding

Table 15.3. Actions for the development of the study tours in Urban Water Management 2015

Pre-trip phase
• The placements of the study trips within the course have been considered carefully to allow the students to relate the trip experience with what they have just learned, to reflect on it, and to apply their learning in the next step. For each study trip, a tour guide was developed with description of the detailed program, projects/places to visit, short introduction of the projects/places, maps/plans, and questions to find out and reflect upon during the trip. • For the tour to Tianjin, in order to give 'ownership' to the students, a pre-trip questionnaire was sent to students to collect input (Appendix I). • The tour programs were planned more carefully. The purpose of the study trip was communicated with the hosts. They were asked to provide basic materials before the trips and professional introduction during the trip. Tour guides were developed based on the basic materials. • In order to encourage the students to be more active in observation and discussion during the trip, a group of questions were assigned to each main site and included in the tour guides. The questions are combination of finding out concrete data or mechanism and questions for inviting reflection. • For the trip to Tianjin, a short pre-trip instruction was given to explain issues like logistic, safety, objectives, sites, questions. Besides, a summary of the students' input from the pre-trip questionnaire was presented. • It is repeatedly emphasized prior to the trip that the students are expected to collect ideas, materials and examples for their group assignment.
On-trip phase
• During the study tour, students are encouraged to ask questions and discuss with the local professionals. They are reminded to search answers to the assigned questions and note down/sketch the answers. Because most guides speak Chinese, Chinese students are invited to be interpreters. The students are encouraged to reflect on the experience on their way home.
Post-trip phase
• The first class after the study tour started with a one hour plenum session to summarize, reflect and discuss with the students on what have been seen during the study tour. Prior to this I summarize the key points and prepare the answers for the assigned questions. • After the written exam, a post-trip questionnaire was sent to the students to evaluate the study trip (see Appendix II).

The results

Pre-trip questionnaire results

Of the 18 students in class, 13 students have answered the pre-trip questionnaire. For how much they like study trips compared with other teaching forms, the average score is 4.7 out of 5. The reasons are: 'We can relate the excursion with the lecture if it is arranged soon after the lecture'. 'They broadened my horizon about urban water management and understanding on how they are carried out in the real world.' 'It is more fun than in-class teaching.' 'Through hearing and seeing, we are easier to find questions and then to get immediate reply from teachers or guiders.' For the future study

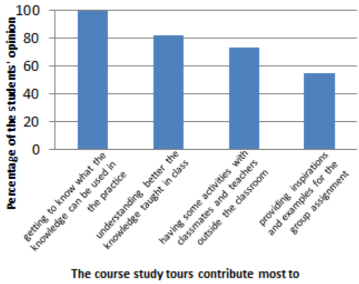

Fig. 15.1. Results to the question ‘what learning aspects do the excursion contribute most’?

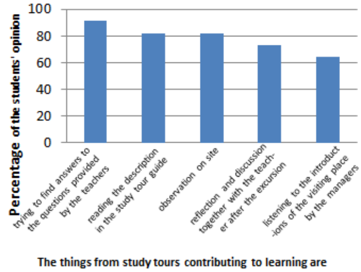

Fig. 15.2. Results to the question ‘what you did for the excursion contributes to your learning’?

tours, the things they want to gain are, for example, ‘an actual and visible example for the theoretical knowledge we learned in class’, ‘to see the actual use of what we have learned, to know whether it works well, to find out what can be improved to some extent’, ‘to learn how to get along with people and how to improve the innovation ability.’ Especially for the trip to Tianjin, the students hoped to have more practical activities and challenges, e.g. exercises to facilitate understanding, ‘to discuss some topics or assigned questions on the site’, ‘to know some background of the site and the purpose of the excursion’, and to ‘include a small discussion or summary about this excursion in the later lectures.’

Post-trip questionnaire

From all 18 students, 11 students answered the post-trip questionnaire.

For the questions on how much they like the study tours especially that to Tianjin and how much have the study trips helped on their learning process, both got an average score of 4.2 out of 5. There were mainly positive comments: For example, ‘I really like the excursion. It is a good way to see how things are carried out in practice, and to give a better idea of the challenges behind’; ‘It mostly fulfilled my expectation. It helped me to better understand knowledge learned in class and earned some personal idea. I thought why we built this eco-city there? Maybe we have better place to choose and how about the real benefit of the eco-city in the future’; ‘The excursion had a lot to do with what we learned in class’; ‘It was very interesting and very helpful. Because many managers gave us more details about the eco-technology and it was also helpful for our group work'; 'It helped me very much on the understanding of how to do it in practice.' There are also less positive comments: For example, 'I have been to places like this before.' Figure 15.1 shows the results to the question 'what (learning aspects) does the excursion contribute most?' Figure 15.2 shows the results to the question 'what you did for the excursion contributes to your leaning?'

Other results referring to study tours

Students referred to the study tours, especially the tour to Tianjin in both the group assignment and written exam. This can be identified in four out of the six group assignments. For example, in a group assignment, the treated water is suggested to be used as water source of the landscape and water quality is suggested to be improved by a park with horizontal subsurface-flow and surface-flow constructed wetland. It is obviously inspired by the wetland park in Tianjin TEDA. In the writing exam, the last question asked students to reflect on the cons and pros of nature-based solution. A student reflected on the eco-city tour: 'Constructed wetland can improve the water quality and also become scenery for recreation. More eco-park or wetland park can improve the biodiversity too'; 'Some methods, like eco-city, really need high quality residents who possess a good environmental consciousness, which is a drawback.' The students also gave a good remark to the study tours in the final course evaluation. For the question 'please list the 1-2 best aspects of the course/what has been profitable', among the total nine comments seven emphasized that the study tours have been very good. For example 'Three excursions were very helpful for us to get practical ideas about what we learned'. It was also observed during the study trips that the students were eager to ask questions, both pre-assigned questions and questions from their spontaneous reflections. For example, in the seminar in the wetland park, one student asked about the water quality of the water in the lake and question whether it is harmful for the wildlife.

Discussion and conclusion

In the pre-trip questionnaire, the students' reflection on the effect of study trips echoes the earlier scholars' statements of the positive roles of field-trip, such as for conscious-raising and problem posting (Freire 1970), and for improving learning by doing (Kolb 1984, Krakowka 2012). The students consciously appreciated that the study trips are well-related with the knowledge taught and they prefer active involvement than passive listening on site. This approved that my hypothesis for this project has been on the right direction to improve learning. The results of the post-trip questionnaire also show that the efforts of improving the study tour were rewarding. The students' referring to the study trips as an important factor for the course's success is an important evidence. Compared with the similar study tours last year when no special attention paid to improve the active learning of study tour and its link to the theoretical knowledge, the experiences from the study tours are better referred and reflected by the students in their assignments this year.

Whenever possible, the study tours, especially the tour to Tianjin, intentionally incorporated Krakowka's and Wong & Wong's theories and experiences into different stages of study tour. It is approved that a relevant and well-prepared study tour is very much preferred by the students, which experienced by the students has good effect on learning, for example supporting the deeper understanding of what taught in-class and motivated by the application of the theoretical knowledge in the real world. Some specific experiences can be drawn through the study tour development of this project:

- It is approved that the pre-assigned questions for each visit site are very effective for encouraging an active learning during the study tour. A carefully prepared tour guide including relevant introduction to the sites and a post-trip reflection/discussion session are also important for learning. Encouraging an active observation by e.g. relating the tour with the assignment and securing a good introduction by professionals are also helpful. The pre-trip introduction is also appreciated by students.
- The post-trip reflection session is good, but as a teacher guiding this session, the author felt that the students did not participate actively enough; therefore it needs to be improved. More instruments need to be introduced to promote their active reflection after the trip.
- It is good to emphasis the need for observation and collecting examples for group work.
- Only one student volunteered to be the interpreter during the tour. Maybe it is better to find more volunteers before the trip for interpretation, since this does promote the interpreter's active involvement and learning. Maybe a short session can be added prior to the trip for ex-

ploring the visit sites via internet. According to the learning circle, this is kind of experiment and will contribute to effective learning.
- The placement of the excursions is important. Excursion is best placed soon after the relevant theory taught.

Due to the time limit, only some basic measures for improving the active learning through study tours are applied, for example developing a question guide to each key site, inviting students' inputs prior to the trip and conducting a reflection session after the tour. Still these limited efforts have contributed to the learning effect of study tours and the apparition for the course. More measures inspired by other scholars' experiences are worth trying in the future and in other courses as well, for example setting off one hour in the class to ask students to explore the tour sites via internet, asking students to take some short reflection notes during and after the tour but before the reflection session, and relating study tours more to the assignments.

Reflection on the discussion with colleague

My colleague Peter Stubkjær Andersen read and commented on this report. He thinks that this is an interesting topic and generally well-written. He especially likes the application of Kolb's learning cycle to fieldtrips and finds it useful for him to arrange fieldtrips from this perspective. 'It will improve the learning outcome for sure'. He criticizes that I had much more actions on pre-trip phase than the latter two phases and suggests I expand focus to the other phases also. He also criticizes that the questionnaires had too few questions – 'Getting more information about students' impressions could be nice'. Finally he suggests that I could have incorporated the concept of institutionalization in the report, which is especially related to the post-trip stage – reflecting on the experience from the trip and put it to the broader learning context.

I think that Peter made some good comments and suggestions. It is true that more efforts should be done during and after the tour. The challenge during the tout is that time for each site is limited. The students are busy on listening, asking questions and making notes. There is often very little time left for making more interactive learning. This could be improved by reducing the sites to visit and really making important ones an effective learning process, by, for example, adding a discussion/reflection session with groups already during the tour. Moreover, to apply institutionalization theory for improving the post-trip reflection stage may improve the results of the project. It has been my intention that I limited the questions in the questionnaire. I did not want the students to feel pressure by these two extra tasks in this short course with rather heavy working load. It has been a great learning process for me to intentionally make effort for improving student's learning. It is especially helpful to relate this practice with the earlier theories and practice. It has been a nice surprise that there have been others who had more experiences and made more thinking on the similar topic. As a teacher it has been encouraging and rewarding to experience that efforts for students do lead to harvest.

Acknowledgement

I pay my gratitude to my colleagues Peter Stubkjær Andersen and Marina Bergen Jensen for their comments on this report, and to Michael May for his comments during the project process.

A The questionnaire questions for improving learning through course excursion

Your name / E-mail: _________________

- How much do you like course excursions in comparison with other forms of teaching, e.g. lecture, in-class exercise, group work etc.: Please give a 1-5 scale (1=do not like; 5=like very much), then explain shortly why you like or dislike?

- What do you want to gain through course excursions?

- What experience do you miss or dislike from earlier excursions in the program?

- Do you have other suggestions for the coming excursion?

B The questionnaire questions for evaluation on the excursions' learning effects

Your name / E-mail: ________________

- How much have the course excursions, especially the last excursion, fulfilled your expectation? Please give a 1-5 scale (1=not at all; 5=fulfilled to a high degree), then explain shortly why you say so.

- How much have the course excursions helped on your learning process? Please give a 1-5 scale (1=not much help; 5=helped to a very high degree)

- What does the excursion contribute most? (You may choose one or more aspects. Please state the more important first.)
  A: Understanding better the knowledge taught in class;
  B: Getting to know what the knowledge can be used in the practice;
  C: Providing inspirations and examples for the group assignment;
  D: Having some activities with classmates and teachers outside the classroom.
  E: Other...
- What you did for the excursion contributes to your learning? (You may choose one or more. Please state the more important first.)
  A: Reading the description in the Study Tour Guide;
  B: Listening to the introductions of the visiting places by the managers;
  C: Observation on site;
  D: During the visit, trying to find answers to the questions provided by the teachers;
  E: Reflection and discussion together with the teachers after the excursion.
  F: Other...

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Improving veterinary students' deeper learning and motivation by stronger alignment in a course of Clinical Anaesthesiology

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Introduction and definition of problem

Veterinary students of the University of Copenhagen will during their university education transfer from mainly auditorium and class room teaching to individual clinical training in a hospital setting with real live patients. This transformation is not only in the setting but also in the way of teaching and learning. Many students experience difficulties in transferring from earlier courses where learning is mostly by perceiving presented knowledge to using knowledge in a clinical setting where the situation is less controlled.

In the course "Emergency, Obstetrics, Critical Care and Clinical Anaesthesiology" this dilemma is evident in the case of the subject Clinical Anaesthesiology: the students have had all their theoretical teaching in anaesthesia before emerging this course but still have difficulties in being well enough prepared for the clinical rotation to get the best learning experience and most gain – ie. deepest learning.

Previous teaching in the subject of anaesthesia:

3rd year (last year on the bachelor level): 3 hour lecture "Principles of anaesthesia and analgesia", part of the course "Small Animal Basic Clinical Theory". The exam is a combined essay and multiple choice exam.

4th year (1st year on the candidate level): 3 hours lecture "Overview of anaesthesia and analgesia", part of the course "Small Animal Medicine, Surgery and Reproduction". The exam is an electronic multiple choice *exam.*

4th year (1st year on the candidate level): Some practical anaesthesia of pigs as part of the course "Surgical Techniques".

The course "Emergency, Obstetrics, Critical Care and Clinical Anaesthesiology" is an obligatory course on the candidate level of the degree in veterinary medicine, year 1 or 2. The course is of one-block duration and commences 4 times a year for up to 45 students at the time. The sub-course Clinical Anaesthesiology consist of 3½ hours of introduction teaching for all the 45 students followed by one week of clinical anaesthesia training in the anaesthesia department of the University Hospital of Companion Animals. During their clinical training the students will be in 8 groups of 3-6 students and each day of clinical work with patients will be rounded off by "rounds" where the teacher and the students discuss the patients of the day and relevant theoretical subjects.

For the course investigated 29 students was listed and completed the course. The 29 students were divided into 8 groups of 3-4 students.

Pedagogic angle and purpose of the study

When supervising the students during their short clinical rotation, I often experience the students being very overwhelmed by the amount of decisions they have to make during their clinical work and how difficult it is for them to make independent decisions. To help them make decisions they need solid guidance to reflect their way based on their existing knowledge rather than trying to know everything by heart and asking for protocols. This tells me that many students are unfamiliar with using their knowledge and reflect on it and its use. This can partly be explained by the massive curriculum in veterinary medicine, and to a large extent by the way we teach, as fast overview lectures promote surface learning rather than deep learning. If we as teachers fail by focusing on only the content of the teaching rather than all three dimensions: content, drive and interaction, the students will find it difficult to learn and develop new competences. Illeris' teaching triangle describes the relationship between content, drive and interaction as two processes: the external interaction process between the individual and the environment and the internal psychological learning process (Illeris 2003). The three dimensions can also be described in terms of knowledge, understanding and competences (content), motivation, feelings and will (drive) and action, communication and cooperation (interaction).

To enhance the outcome even further in terms of deeper learning we could benefit from Biggs' constructive alignment model that describes the relationship between curriculum aims, teaching-learning activities and evaluation and how these three elements condition the student's learning. According to Biggs and Tang all learning is a result of student activity and constructive alignment will promote deeper learning of the students.

These theoretical thoughts result in the following purpose of this project in university pedagogy in relation to the teaching of Clinical Anaesthesiology in the above mentioned course:

How can stronger alignment between the course's curriculum goals and teaching-learning activities contribute to deeper learning of the students and thereby prepare them better for their clinical training?

The stronger alignment in this investigation does not include the final evaluation form of the course, as it is given as a multiple-choice exam based on clinical cases preferably.

Changes made in the project design based on input from colleague

Based on the description of the project a colleague asked the following questions: What is it that you want to investigate: Motivation, deeper learning or the students' responsibility for their own learning by improving constructive alignment? As this was not clear from the project description, a more strict purpose was developed according to the above mentioned purpose.

Also a part regarding the practical exercises rounding off the introduction teaching day was included in the project proposal but his part was removed in the final project as it spread out focus.

Description of the course and interventions

The main changes made in the course of Clinical Anaesthesiology to investigate the purpose of this project are made in the 3½ hours introduction teaching and to a lesser degree during the clinical rotation.

Original course

In earlier forms of the course most of the theoretical teaching of the introduction day was repetition of subjects related to clinical anaesthesia according to this plan:

08.30 - 09.10: Short introduction to most used anaesthesia protocols

09.10 - 09.40: Theoretical exercises in groups: ASA-classification and choice of anaesthesia protocol

09.50 - 10.10: Introduction to anaesthesia monitoring

10.10 - 10.50: Theoretical exercises in gruops: Identification of anaesthesia complications and possible treatments

11.00 - 11.20: Presentation of The Anaesthesia Department (introduction to the students' clinical rotation)

11.20 - 12.05: Practical exercises in groups: Intubation and intravenous catheter

In teaching former courses I have often had the feeling that most of the introduction day was spend reviewing formerly taught curriculum. The students seemed happy and found the review good and informative and I could observe an improvement in their knowledge compared to earlier courses without introduction teaching. However they were still overwhelmed by the transfer to clinical work, and my wish was to make them more prepared for clinical work and me giving less reviewing lectures. These are the main reasons for the changes made in the investigated course.

Investigated course including changes to achieve more alignment

In the present version of the course the following changes were made in order to enhance alignment:

Curriculum aims (listed in question number 1 in the questionnaire, appendix 1) from the course description were presented in more detail for the students and operational teaching aims were made from these to make the purpose of the course even clearer for the students. (Operational teaching aims are listed in question number 3 in the questionnaire, appendix 1). The presentation of these aims also made it possible for the students to match their expectations with the teacher's and set the frames for the teaching.

The introduction teaching was planned to prepare the students to their clinical rotation rather that reviewing formerly presented curriculum. A reviewing Power Point presentation was available for the students to assist in their preparation for the introduction teaching instead and the teaching toke the starting point in how I as an anaesthesiologist plan an anaesthesia for a patient. The interactive dialogue-based presentation of a real case was followed by group assignments where the students in small groups were asked to go through other cases as just demonstrated answering various issues relevant for the cases. Some of the cases (time did not allow for all cases to be presented and the students were told that initially) were then presented by the students for the whole class and discussed.

By letting the students solve their own cases after a demonstration let to the use of their knowledge and reflection and prepared them theoretically for what they would be doing during their clinical training in practice, and hopefully motivating them for deeper learning.

By giving the cases to solve as group assignments the students were forced to work as a team which is also of great importance in a hospital setting, where the members of a team make their competences available for the team as a whole. The case-angle also illustrated the problem-oriented way of preparation rather than the page-by-page reading.

An individual assignment was given to the students to sum up the theoretical introduction teaching: They were asked to make a mind map taking focus in "Anaesthesia". This was done to let them reflect on the many aspects of the subject and to relate it to other parts of veterinary medicine. They were also encouraged to use their individual mind map as an inspiration for further studying before their clinical rotation as the mind map might have illustrated less well understood issues.

These changes resulted in the following plan for the introduction teaching:

08.30 - 09.10: Presentation of The Anaesthesia Department (introduction to the students' clinical rotation)

09.10 - 09.40: Demonstration of a case: "How to plan an anaesthesia" – taking starting point in the operational teaching aims.

09.50 - 10.30: Theoretical exercise in groups: Patient cases – how to ASA-classification, what anaesthesia protocol, how to monitor and how to manage analgesia?

10.30 - 11.00: In plenary: Presentation of some of the cases and discussion

11.00 - 11.15: Round up and final assignment (mind map)

11.20 - 12.05: Practical exercises in groups: Intubation and intravenous catheter

Evaluation form and investigation methods

To evaluate the effect of the changes made in the introduction teaching a Danish questionnaire with 21 questions was made based on the usual evaluation form for the course and supplementing questions regarding:

1. Effect of curriculum aims and operational teaching aims
2. Evaluation of group assignments
3. Alignment of curriculum aims, teaching-learning activities and clinical rotation
4. How well prepared the student felt him/herself for the clinical rotations
5. How motivated the student felt for further studying and deep learning

All questions were rated 1-7 (e.g. not at all - very much or unacceptable - optimal) or not relevant. The students were given the questionnaire within 2 weeks after completion of their clinical rotation and the quantitative data were supplemented with qualitative data as the students could write comments to relevant questions. A total of 29 questionnaires were handed out and 24 completed and returned, representing all 8 groups of students in the block. The completed questionnaires were anonymous except group number.

Some of the questions in the questionnaire will be compared to the results from the final evaluation form from the students in the block before the subject of this study.

All results will be given as mean. Relevant comments from the students will be included in an illustrative way.

Presentation of results and experiences from the study/intervention

Overall the subcourse Clinical Anaesthesiology is rated as a very relevant course for the students (mean 6.64) and the students find the course material close to optimal (mean 6.09). The students find the teachers near optimal as clinical supervisors (mean 6.91), the assistance/guidance during the clinical work very good (mean 6.41) and the university hospital/department a near optimal place for teaching (mean 6.55).

Effect of curriculum aims and operational teaching aims

The students found that the course highly took its starting point in the curriculum aims (mean 5.81) and these were made clear from the start (mean 5.77). These results are better than the in the former block (before interventions) as these questions only scored 4.86 and 4.14 respectively. The add-on of the operational teaching aims improved the students' understanding of the curriculum aims (mean 6.18), thereby indicating the need for more tangible aims to enhance understanding.

Evaluation of group assignments

The students found the learning of the theoretical case assignments more than acceptable (mean 4.52) but the spread among the students was high (minimum 1, maximum 7) and the learning was less than amongst the students of the former block (mean 5, minimum 4 and maximum 6). The feedback of the theoretical assignments was well accepted (mean 5.28) and on level with the former course, however the spread was again higher than before (minimum 1, maximum 7). An explanation to the high spread of the students' learning from the cases can be the fact that not all cases were reviewed and discussed in plenary – despite this being mentioned from the start; so students who's cases did not get reviewed and discussed may be the students who respond with low scores and comments like "There was not enough time for the assignments", "I think the learning would have been better if there had been more time", "More time to review ALL cases" and "More time to review the cases to actually get feedback!". In contrary other students responded with comments like "The concept is really educational", "A good educational assignment. Good choice to work in groups so that you can discuss and hear different arguments. Nice with an introduction to the assignment.", "...it was a good way to be introduced to the way of thinking in the department.", "...having been through a theoretical assignment made it easier to transfer it to practice".

Alignment of curriculum aims, teaching-learning activities and clinical rotation and its effects

The mean for the question regarding the students' experience of alignment between curriculum aims, teaching-learning activities and clinical rotation was 6.00 and thereby scores near optimal of the students.

The students themselves felt more than acceptable prepared (mean 5.27) for their clinical rotation based on the introduction teaching and their own preparation and they felt a near optimal (mean 6.14) motivation for self-studying and deeper understanding.

The students found the teaching outcome of the clinical rotation very high (mean 6.50) and were very highly in agreement of this point (minimum 5, maximum 7). They had many positive comments related to the clinical rotation, and these are some of them: "It is great to be responsible for your own patients, and to get as much hands-on as possible.", "Small groups make it possible for all to get answers to questions.", "It worked really well when you followed a patient from start to end and was able to see parameters change during anaesthesia." and "Really good when we have had to explain or answer questions, as you learn more compared to just listening."

On the question "How was the relationship between theoretical teaching ("Rounds") and clinical teaching?" the students answered near optimal (mean 6.41). Their comments included "The combination of the practical hands-on in the operating theaters and the possibility of theoretical talk has been good.", "It was super nice with rounds where we could discuss the questions you had come across during the day." and "Really good with rounds in the afternoon." These comments make it clear to me that it is important for the students to have a place to go with their questions and that giving them this possibility by having rounds enhance their reflection and thereby deeper learning.

Discussion and conclusion made upon the results from the study

The high degree of the curriculum aims being the starting point for the teaching and the increased understanding of the curriculum aims by writing up operational teaching aims correspond well with the triangle of learning by Illeris which illustrates the relationship between content and interaction, here illustrated by enhanced understanding by improving the relationship between the desired competences and the clinical relevance. To list specific wanted competences (e.g. "the student should be able to plan and perform the most optimal anaesthesia/sedation procedure for the individual patient and procedure" or "plan postoperative analgesia") as operational teaching aims as an alternative to the more "fluffy" curriculum aims (e.g. "Be able to evaluate and choose the correct form of sedativae, analgesia and anaesthesia..."), the students will easier understand what they will have to learn as it becomes more clear.

On focusing on the theoretical assignments, the cases, the acceptable level of learning is good but the large spread of result amongst the students with regard to the feedback make to opposites. These two opposites make it clear to me as a teacher that to enhance the outcome and deep learning of all students they need feedback on all their assignments. This fits well with Biggs' constructive alignment model where testing is one of the three components (aim, teaching-learning activities and test) that allows deeper learning (Mørcke & Rump 2013). The test in this context is seen merely as an evaluation of the students' abilities to solve the assignments correctly and will thereby also tend to boost the students' motivation if successful. One student commented "More teaching instead – it is the teachers who have the answers." This to me is a clear example of a "surface"-learner who has yet not gasped the concept of leaning in a more advanced state. To get this kind of student to understand the learning concept used in this course, there is a need for more explanation of why the teaching is done the way it is.

A near optimal alignment of the curriculum aims, the teaching-learning activities and the clinical rotations is a very positive indication of successful alignment not only to me as teacher but also recognized by the students. However the main purpose of enhancing alignment of this course was to improve the students' deeper learning and prepare them better for the clinical rotation.

Both the level of preparation for the clinical rotation and the motivation for deeper learning and further self-studying were high and correspond well with the good achieved alignment level in this investigated course.

These results indicate to me that enhanced alignment of a course will lead to deeper learning of the students and maybe do so by enhanced motivation. In the current investigated course of Clinical Anaesthesiology a stronger alignment between the course's curriculum goals and teaching-learning activities contributed to deeper learning of the students and thereby prepared them better for their clinical training. Hence, the project was successful.

Perspectivation and potential limitations of the project

In this current project of stronger alignment, the stronger alignment is successful in preparing the students better for their clinical rotation and enhancing their motivation for deeper learning.

Stronger alignment could be a way of improving deeper learning of the students in other courses and surely makes a red line throughout the teaching experience. The strong focus on curriculum aims and more practical operational teaching aims makes it easier to keep focus during teaching – both during planning and execution.

However the stronger alignment only refers to the alignment of the curriculum aims and the teaching-learning activities, hence it does not relate to the testing of the students' competences. If the exam fails to align with the rest of the course there is a risk of the students not being tested correctly in the curriculum and they will maybe not be as motivated to follow the alignment way during teaching as the goal is somewhat different. – if the motivation for passing the exam is greater than that of learning we have obtained too little.

Therefore it is a limitation of this project that the exam is not included in the alignment changes and to fully benefit from the great advantages of constructive alignment in a course the alignment of the exam or test should be included.

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Can student's learning outcome be improved by modified guided inquiry learning?

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Introduction

University teaching has evolved during the last decade to actively include students in courses using approaches such as theoretical exercises, laboratory exercises, quizzes and dialog among teacher and students. There is however still challenges that needs to be addressed in the current educational system. At University of Copenhagen, three hour blocks of lectures are currently not uncommon and if the lecturer is a guest and not the course responsible it may not be feasible to develop laboratory or theoretical exercises to activate students. Student activation is an important method to maintain student attention throughout the lecture (Bunce et al. 2010) and furthermore studies show increased understanding and learning outcome when active learning approaches are implemented as supplements to lectures (Brown 2010, Freeman et al. 2014). If the short attention span of students is ignored and traditional lecture format is continued students learning may be compromised.

According to the Structure of Observed Learning Outcome (SOLO) taxonomy of learning, students learning can be evaluated by 5 groups/steps of learning outcomes (Mørcke & Rump 2013). SOLO steps 4 and 5 summarizes the deep learning process where students learn to analyze, interpret, use (step 4) and develop new hypotheses and perspectives (step 5) from the learned topic. In the following, skills obtained in SOLO steps 4 and 5 are designated as higher level thinking skills. In this project the objective was to increase students understanding and deep learning by including disruptive elements in the lectures in the form exercises inspired by a semi-inductive approach and guided inquiry learning. These exercises will in the following be represented by the term modified guided inquiry learning (MGIL). Inspiration and the scientific validity of guided inquiry learning is found in results produced at Washington University in St. Louis, MO, USA where courses in science, technology, engineering and mathematics (STEM) have been successfully improved by process-oriented guided inquiry learning (POGIL) (Eberlein et al. 2008). he aim is to facilitate deep learning among students as they work through small exercises of which the theoretical background is unknown. Through discussion with peers, students will reflect on the issues presented and hopefully this way form new elements of knowledge to construct additional knowledge from.

Problem statement

Activation of students is critical to obtain efficient knowledge transfer during lectures. Especially guest teachers may benefit from the use of short and informative exercises in a format using modified guided inquiry learning (MGIL). But how do the students react to this approach? This is not known. In the current project the following questions will be answered:

Q1: Do students understand key points conveyed by MGIL 6 months after the session?

Q2: Do students feel that MGIL benefit their learning?

Q3: What are the challenges when using MGIL in lectures from the students' perspective?

Background

MGIL was applied in the bachelor course Plantevidenskab at University of Copenhagen. Students attend the course on their 3rd year as part of the BSc program Natural Resources. Course topics are breeding, growth, production and quality of plants. The course is placed in block 2 in timetable groups B and C and yields 15 ECTS points. Students follow lectures and simultaneously work on selected research projects in groups. The exam form is multiple choice questions covering lectures and the deliveries and defense of a project report. Two 3 hour lectures were designed to include MGIL exercises at 15-20 minute intervals to disrupt the monotonous nature of the traditional lecture. In lecture 1: Kvalitet og kontrol af ethylens virkemåde, 10 of the 16 enrolled students attended. In lecture 2: Bioteknologiske metoder i produktudviklingen af højværdiafgrøder, 11 of the 16 enrolled students participated. The learning objectives for lecture 1 and 2 are presented in Danish in Figure 17.1.

Results and discussion

Students of Plantevidenskab received a questionnaire 6 months after course completion (Appendix A). The questionnaire contained basic questions related to lecture 1, lecture 2 and to how students perceived the two lectures. Of 16 possible students, 7 students which attended the lectures replied – yielding a response of 64%.

Forelæsning 1: Læringsmål

Kendskab til hvilke parametre der beskriver kvalitet

- Målgruppe
- Frugt
- Prydplante

Viden og forståelse for ethylens virkemåde

- Syntese
- Plantespecifikke forskelle
- Brug i den virkelige verden

Forelæsning 2: Læringsmål

Kendskab til metoder der benyttes i produktudviklingen af højværdiafgrøder

- Genetisk variation
- Transformation
- Naturlig transformation

Viden og forståelse for naturlig transformation

- Oprindelse
- Overordnet mekanisme
- Klassiske fænotyper

Fig. 17.1. Learning objectives in lecture 1 (Kvalitet og kontrol af ethylens virkemåde) and 2 (Bioteknologiske metoder i produktudviklingen af højværdiafgrøder) in the bachelor course Plantevidenskab. Objectives are in Danish as the course is running in Danish.

Students understanding and recall of knowledge conveyed to them in lectures 1 and 2 were surprisingly good. Even though the questions are simple and easier than exam questions on the same topic a person with no prior knowledge would not be able to answer. In some replies students commented... "Ja, det mener jeg?".. or .."husker ikke".. or .."ved ikke"... This indicate that they followed guidelines as directed in Appendix A and did not cheat by searching online for answers. Actually a student commented ...“ Jeg husker forbløffende meget (ved jo ikke om jeg husker rigtigt :))”... As to the point raised in Q1, if students’ still understand key points of the lectures 6 months later – they do, at least 64 % of them. However if MGIL is responsible for this cannot be determined in this context. Uncharacterized factors may influence the result such as personal interest in the topics or the close relation of the topics to the students’ everyday life (as the features discussed address flowers and fruits).

The MGIL exercises were well received by the students. On the day of the lecture they found the exercises strange (my view) due to the low amount of prior knowledge given to them beforehand. However, when asked 6 months later many of them were positive to the approach using exercises first and the theoretical part covering the exercise afterwards. When asked if they liked the use of exercises before lectures student remarks were ...“Både og; det skærper nysgerrigheden for at få svar på de spørgsmål man nu ikke kunne svare før forelæsningen, men samtidig er det godt at opsummere og afslutte forelæsningen med øvelser”... “Ja – Men kun hvis det bliver brugt aktivt som appetitvækker. – Noget som vækker appetitten. Det kan også blive for elementært når det netop er før oplægget”... “Generelt virker det godt at have øvelser inden forelæsning. Dette kan være med til at sætte fokus på hvad der er vigtigt i forelæsningen, og viser hvad teorien kan bruges til”... “Jeg tror at indlæring øges når man stimuleres til at tænke selv”... in contrast a student found it .. “ret irriterende”... None of the students believed the order of exercises versus lectures had any effect on their learning and therefore also did not identify any connection between MGIL and improved learning (answer to Q2). However all students found the presence of exercises pivotal to their ability to acquire new knowledge. Representative comments to the importance of exercises on their ability to learn were... “Øvelser er meget nødvendige”... “det er svært bare at huske en talestrøm”... “ Ja!! (øvelser er vigtige)”... “Det er alfa omega. – og for mig forskellen på at kunne nogle facts, og sætte dem ind i en sammenhæng”... Considering student experiences exercises should always be included in lectures in some format. Depending on the topic, time span and if the lecture is a returning event, teachers have multiple options. If focus is on the guest lecturer which teaches once or twice a year, there is a need for exercises in a format that is cheap, do not need laboratory equipment and can be completed during the available timeslot. MGIL exercises could be good candidates for this.

Students from Plantevidenskab identified some shortcomings in the used format of MGIL (Q3). Exercises where in some cases too simple... "Nogle af dine øvelser var måske lidt for nemme - måske netop fordi de kom før teorien"... "Det kan også blive for elementært når det netop er før oplægget"... As a rule easier exercises where placed in the beginning of lectures, they were used to warm up the students and to facilitate a gentle introduction. The more difficult exercises were placed later in the lecture; students may have forgotten these 6 months later. Examples of easy and difficult exercises are presented in Appendices B and C, respectively. As this was the first year MGIL was introduced to Plantevidenskab it was challenging to estimate the students prior knowledge especially with regard to their knowledge on basic plant physiology and molecular techniques used in plant sciences. These topics can with benefit be more integrated in the exercises applied in the course during winter 2015 thus accommodating students' wishes.

One of the limitations of the study is the low response rate of 64 %. If the responding students represent the full group or if only students knowing the answers replied is not known. Also, students were asked to answer questions without the use of notes, the internet, but if they followed this instruction cannot be determined in the current layout. Additionally monitoring student learning in a control lecture not using MGIL, but using the same group of students could have been informative, however this was not possible to include in Plantevidenskab in the 2014/2015 period.

Conclusions

MGIL exercises were successfully implemented in the bachelor course Plantevidenskab at University of Copenhagen. The purpose of exercises was to keep students engaged in lectures spanning 3 hours including pauses. Also exercises were applied to help student's learning and understanding of the theoretical material. On lecture days student and teacher interactions were frequent and the learning environment was active and engaging. 6 months after the course the recollection of the basic points of lectures were well preserved. Students could remember effects of ethylene on plants and basic ethylene biology (lecture 1) and principles from biotechnological methods described in lecture 2. Students were positive towards MGIL exercises 6 months after the lectures but were sceptic as to the effect of these exercises on their learning. They all however stressed that exercises in general had a positive effect on their learning. In retro perspective MGIL exercises can be expanded in the next course period to include more challenging material and to stretch over longer periods. This may be possible in the next course period due to more time in the planning phase and a better understanding of student's prior knowledge when starting the course Plantevidenskab.

Perspectives

MGIL exercises are a fusion of semi-inductive exercises where all new knowledge generated are developed from the students and POGIL exercises which take place in highly structured student groups with teacher assistance. In POGIL the key point is that students help each other to realize new principles and ways of thinking. Common for both types of exercises is that students themselves realize how biological problems arise, can be solved and which components are necessary in this process. In such cases there is a higher chance of long-term retention of knowledge. The utility of POGIL exercises is well documented. In a pharmaceutical course higher level thinking skills were improved when student's exercises were designed to fit the POGIL strategy (Soltis et al. 2015). Low level thinking skills were unchanged but for exam questions requiring higher level thinking increased performance of students exposed to POGIL was found. In higher level thinking questions students are required to analyze and apply their knowledge as described by SOLO taxonomy. Also significant increases in student grades attending medicinal chemistry with included POGIL exercises have been reported (Brown 2010).

A Questionnaire

Kære tidligere studerende ved temakurset Plantevidenskab

Jeg havde fornøjelsen at undervise jer i efteråret i to forelæsningssessioner under temaet højværdiafgrøder:

A: Kvalitet og kontrol af ethylens virkemåde
B: Bioteknologiske metoder i produktudviklingen af højværdiafgrøder

Jeg er ved at afslutte kurset Universitetspædagogikum, et kursus der bruges til uddannelse af kompetente undervisere på KU. I denne sammenhæng vil jeg bede jer svare på nedenstående spørgsmål. Jeg kan bruge jeres svar som feedback på den udførte undervisning og til at lave forbedringer for de kommende studerende på samme og på andre kurser hvor jeg skal undervise. I får til gengæld mulighed for at præge hvilken undervisningsform jeg vil bruge i fremtiden.

Jeg er tilfreds med korte svar – ja, nej, ved ikke er fint. Uddybelse er velkommen hvis I har lyst til dette ved nogle spørgsmål. Det er ikke min mening at I skal google eller kigge på gamle tekster for at svare, et ligefremt svar efter kort refleksion er perfekt. Jeg er interesseret i hvad I husker på nuværende tispunkt og hvordan I oplevede forelæsningerne dengang. Alle må gerne svare også de af jer der ikke deltog i den enkelte forelæsning.

I kan svare i det vedlagte Word dokument (gem og send den nye version) eller skrive direkte i teksten nedenfor og derefter svare på mailen. Jeres svar vil blive behandlet fortroligt og vil ikke blive sammenkædet med den enkelte studerende på noget tidspunkt. Jeg skal kun bruge data givet af jer som gruppe.

Spørgsmålene kommer her nedenfor. På forhånd tak, Josefine

Spørgsmål der refererer til forelæsning A (kvalitet, ethylen):

Er ethylen et næringsstof?
Er ethylen et plantehormon?
Er ethylen en væske?
Ordet klimakterisk referer til hvordan planten responderer på ethylen un-

der modning eller blomstring. Er en klimakterisk plante følsom overfor ethylen?
Øges holbarheden af frugt og blomster ved tilførsel af ethylen?
Kan planter lave ethylen?

Spørgsmål der refererer til forelæsning B (bioteknologiske metoder):

Er et plasmid opbygget at jern (Fe), mangan (Mn) og andre mikronæringsstoffer i lige dele?
Er et plasmid opbygget af DNA?
Er et plasmid altid genmodificeret?
Styrer en promoter sekvens hvornår et genprodukt bliver lavet?
Koder en promoter for hvilken antibiotika resistens der overføres til planten?
Hvad kaldes overførsel af nyt DNA til en plantes genom - transformation? eller bioinformatik?

Spørgsmål der refererer til undervisningsmetoden benyttet i begge forelæsninger:

Deltog du i forelæsning A (kvalitet, ethylen)?
Deltog du i forelæsning B (bioteknologiske metoder)?
Forelæsningerne var afbrudt af øvelser. Husker du nogle af emnerne behandlet ved øvelserne?
Hvis ja, hvilke?
Tror du skift i undervisningsformen har betydning for din indlæring?
Øvelserne kom før teorien om deres specifikke emne, synes du det format skal bruges oftere i andre forelæsninger?
Tror du det har betydning for din læring hvilken rækkefølge øvelser og teori kommer på?
Har det betydning for din forståelse af et emne om du har øvelser i emnet?
Har du et bud på hvordan fordelingen skal være mellem forelæsning og øvelser for at være optimal for din læring?
Har du brugt elementer fra forelæsning A og B efterfølgende i andre fag?
Har du spørgsmål til mig eller kommentarer?

På forhånd tak for hjælpen,
Josefine Nymark Hegelund
Assistant professor, KU
jnh@plen.ku.dk

B Easy exercise

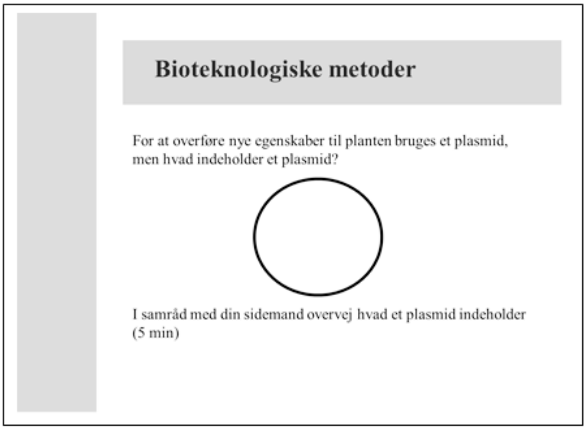

Fig. 17.2. Students' results are discussed in plenum.

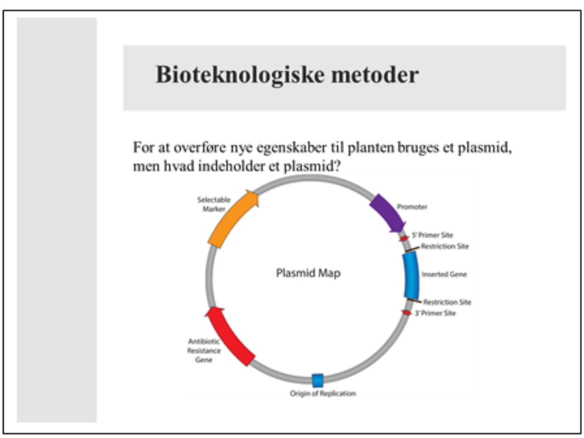

Fig. 17.3. Summary of results from the exercise.

C Difficult exercise

Case: En forædler af *Campanula* sprøjter sine planter med et giftigt kemikalie indeholdende sølv (STS) for at forhindre at plantens ethylen signal resulterer i nedvisning af blomster.

Han søger hjælp til at oprette en renere produktion for både personale og miljø.

Dine indledende analyser viser at C. *xxxx* er ufølsom overfor 0.1 $\mu l \cdot L^{-1}$ ethylen i 72 timer når denne art sammenlignes C.*portenschlagiana* og C. *formanekiana*. Forsøgsresultaterne er noteret i nedenstående skema (Tabel 17.1). Blomsternes fænotype blev klassificeret som: **Brug Tabel 17.2 til**

Table 17.1. Opgørelse af ethylenforsøg i *Campanula*.

Ethylen	*C. portenschlagiana*		*C. formanekiana*		*C. xxxx*	
0 $\mu l \cdot L^{-1}$	1	1	1	1	1	1
0.1 $\mu l \cdot L^{-1}$	1	2	1	2	1	1
Tid	0 h	72 h	0 h	72 h	0 h	72 h

at forklare hvad der kan være sket i C. xxxx's ethylen signaltranduktionsvej. Sæt et kryds i tabellen hvis forholdene vil kunne resultere i C. xxxx's fænotype. Students' results are discussed in plenum.

Table 17.2. Skematisk oversigt med mulige forklaringer på ethylenufølsomheden der blev observeret i C. xxxx. A; et eksempel på et ethylen biosyntesegen. B; et eksempel på et ethylen receptorgen. C; et eksempel på et gen der udløser det fysiologiske respons

Gen	A (syntese)	B (receptor)	C (respons)
Overskud af genprodukt			
Mangel på genprodukt			

Correct answers: Lack of gene product B and C could in principle result in the missing response to ethylene exposure seen in C. *xxxx*.

18

Improving teaching-learning activities for a flipped-classroom course

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Introduction

My main focus for this teaching intervention was to make the students DO - think, write, communicate and reflect over the topic, methods, results and perspectives of the original, scientific papers read in the master-level colloquia-based course “Principal Subjects in Immunology and Metabolism” at the Department of Biology at University of Copenhagen.

The intended learning objectives of the course are to gain knowledge about immunology and metabolism but also to obtain skills in reading original scientific literature critically, to combine gained knowledge to new ideas, to be able to present and defend a paper and to sum up a topic and write it down in a review-like assignment.

In this assignment I deal only with Module 1 of this course, which course runs over 3 Modules, where Module 1 and 2 revolve around paper reading and presentation. The gained knowledge and skills are put to use in Module 3, where the students have to pick a topic, write a review, present it and defend it – no classes, just individual work. TLA’s, with increasing difficulty, for improving students’ writing skills (write an abstract, a popular scientific assay, a summary of a paper) will be introduced in Module 2.

In Module 1 and 2 the course consists of 3 hours of class-room teaching, 1 guidance hour and 22 hours of homework per week. Students are given 2 papers for each week with the purpose to read them between classes and then be able to ask questions and have a discussion about them during class. Each student is to present one paper (15 min PowerPoint presentation) to the class at least once during the course.

Structuring 22 hours of homework dealing with high-ranking scientific papers is not an easy task. Neither is being critical towards published papers written by experts in the field or to fulfil the rather elusive demands for passing the course – asking questions, have a discussion, participating actively.

Accordingly, the level of deep understanding of the papers, the methods, results and impact can be rather low. For example, after a presentation of a paper, the presenting student was asked to explain in his own words what the papers was about - he was not able to say anything!

Theory

To reach the higher levels of learning as described in Blooms taxonomy I base my intervention on the method of Constructive Alignment described by Biggs & Tang (2011*a*).

The idea is, by aligning the Intended Learning Objectives (ILOs) with appropriate Teaching Learning Activities (TLAs) and Assessment Tasks (ATs), students will work and learn on higher levels of Blooms taxonomy such as to combine and integrate knowledge, reflect and judge validity of results and assemble and design hypothetical experiments. An important part of this process is changing the role of the teacher as an organ of knowledge transfer to a person facilitating and guiding the students to reach these higher levels of deep learning.

The online-based collaborative learning-environment is a rather complex "creature", where many considerations about both didactical and technical character has to be carefully considered - as illustrated in the didactical holistic model for planning internet-based teaching presented by Christensen and Søndergaard and shown in Figure 18.1. This model consists of the classical didactical triangle showing the interaction between teacher, student and the topic – and on top of that, another triangle with the interaction between the overall pedagogical, technological and organizational framework of the course.

Of specific considerations for the teaching intervention presented in this assignment was the choice of online platform (technology) for the course. First of all, it is important that the online platform is introduced in order to facilitate deeper learning; in this case to introduce collaborative learning between classes. Furthermore, the online tools have to be well suited for the purpose, in this case annotation of pdf-files and sharing of documents,

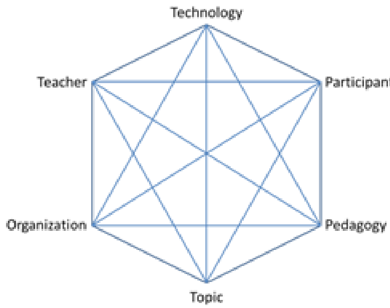

Fig. 18.1. Didactical model for planning of internet-based teaching (redrawn from Christensen & Søndergaard (2009)

and not create (too many) problems or frustrations for either students or teachers.

Another consideration was the role of the teacher in the online part of the course, the collaborative annotation. The visibility and presence of the teacher is obvious in classical face-to-face class teaching, and must not seem absent when doing internet-based teaching. The goal of this teaching intervention was for the teachers to facilitate reading of the papers by posing questions in the text and acting to guide answers in the right direction and validating correct answers.

Finally, inspired by the didactical framework for internet-based collaborative learning described by Agertoft et al. (2003), the role of the students was considered. The goal was to make the students feel part of a group of people who jointly are constructing a common knowledge about the topic by answering questions from teachers, to have questions answered by other students and answering questions from other students in a dialogical process. Thus giving the students both responsibilities for their own learning and for the group as a whole; ideally obtaining the feeling of participating in a common learning process. This goal can be reached when students (and teachers) are communicating through dialogue and conversation with a high degree of participation as shown in Figure 18.2.

The goal with this teaching intervention was to get students to place themselves in the quadrant of Conversation, by writing answers, responses and collaborating in finding the correct answer, characterized by a high degree of participation and low degree objectiveness. This will increase deeper learning for most students as described by Gynther (2005) and

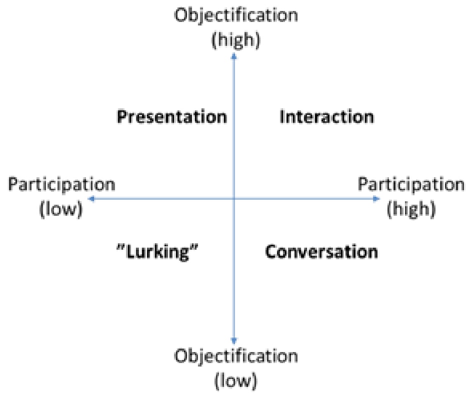

Fig. 18.2. Model of communicative of practice (redrawn from Gynther (2005))

Christensen & Søndergaard (2009). However, some students might deliberately choose the "lurking" strategy, where they seem to passively be observing without participating and learning, but this student-type might rather be gaining insight from own reflections (Christensen & Søndergaard 2009) and the course should leave room for these students as well.

Methods

In this teaching intervention I focus on improving the structure of the weekly scheduled 22 hours of homework, where a lot of time is spend by the students with very little learning outcome as results. Thus the purpose of this University Pedagogy Project is to improve the between-class TLA's for this course to make the students better meet the ILO's.

During teaching in the fall of 2014 I introduced the following new TLA's:

Introduction of between-class assignments the students have to present class

This activity serves to make the students think about what they read in another way and learn from different ways of solving a problem by other students. In the beginning the assignments will be easy (3 things you googled while reading the paper), with increasing difficulty corresponding to the gained skills (Make a hypothesis of the immunological pathways linking the gut bacteria to low grade inflammation in adipose tissue).

Purpose:

- To give more structure between classes.
- To help the students relate to the paper, think creatively, differently and to use gained knowledge in a new way.
- To facilitate peer-teaching. Students can get inspired by how other students chose to solve an assignment.

Embedding questions from the teachers into the papers, which are to be answered while reading

Some questions serve to guide the students in how to read a scientific research paper, by emphasizing small things, such as a statement, a result, a method (What is an SPF-mouse? What does an increase in fasting insulin, but not fasting glucose, indicate in terms of insulin sensitivity and glucose tolerance?). Some questions serve to make the students think about the paper they are reading, the results presented to them, such as to assess whether or not a result I reliable, a specific method is the best suited for the purpose or to judge the validity of conclusions presented in the paper (Look at the figure – are you convinced that NF-kB is activated? What are the pros and cons of this method?).

Purpose:

- To help identify what is important, and not so important, in a paper.
- By answering the embedded questions from the teacher, students can assess their own understanding of the paper.
- To facilitate critical reading of the paper, by asking detailed questions about the coherence and validity of the results presented and the methods used in the papers.
- To guide the reading of the papers a critical, scientific direction.

Introduction of an online platform for interaction with teachers and other students between classes

Here the students not only have access to all the papers, but also the possibility to interact with each other and the teacher between classes. Students can ask questions to each other or the teachers, answer questions from other students before the teachers does and comment on each other's answers.

Purpose:

- Students have an online, social "room" for studying while not in the classroom.
- To facilitate peer-teaching. Students can help each other answer the embedded questions; they can discuss the answers and pose new questions.
- The teacher can assess which students are active (the course is passed by active participation)
- The teacher can see where the students have conceptual problems and put emphasis on that in class (and leave out the easy bits)

Implementation

The working methods and purpose of the interventions were carefully introduced in the very first lesson of the course, with emphasis on the skills the students are supposed to gain during the course, how they can achieve this by using the tools and activities introduced and the rules for active participation and passing the course.

participation and passing the course. Google Drive was introduced as a common platform for all the activities on the course, both during and between classes. One week before the course the students were asked to create a gmail-account in order for them to get access to the course material. The course folder on Google Drive is used as a common course platform for sharing information from the teachers, such as the papers to read, a detailed plan for the course with a list of papers to read each week, the topic they cover and the between-class assignment. Furthermore, the course folder was also used to share the student presentations, secondary literature from teachers or students, and to deliver assignments.

Google Drive is a very dynamic tool, where everyone who is invited to a folder can interact in different ways. It is possible to upload, download, comment and edit documents in the shared folders; all activity is recorded and can even be followed in real time, when for examples writing simultaneously in a document.

1. Weekly assignment:

   The weekly assignment was shortly and relatively loosely introduced as the last thing before the end of the lessons. This approach was used in order for the students to understand what we would like them to do without putting to many restrictions on how to do it in order to make them solve the assignment in their own (creative) way.

2. Embedding of questions in the papers by teachers:
   For the collaborative annotation the students were asked to download the Notable PDF application available for Google Drive, a tool which makes everyone able to comment, highlight, strikethrough, mark etc. in a pdf document, in this case the papers the students have to read for each week. Notable PDF was used by the teachers to ask questions to specific parts of the text in order to increase the learning outcomes. The students were asked to access the paper and answer at least one question in each paper in each week. Teachers used the collaborative annotation to give hints for answering unanswered questions, guide answers in the right directions, validating correct answers or asking secondary questions to answers.
3. Using the online collaborative platform between classes:
   Apart from answering questions from the teachers, the students were encouraged to use Google Drive/Notable PDF to read the answers to teacher-based questions from other students, to elaborate or correct other students answers and to pose new questions themselves in order to ask for help from other students when a particular paragraph/topic/method etc. was incomprehensible instead of getting stuck alone.

Figure 18.3 shows an example of teacher questions and student answers in one of the papers.

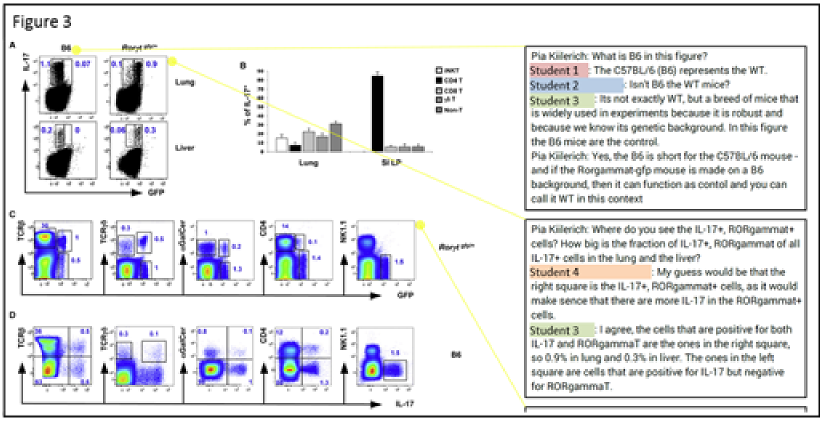

Fig. 18.3. Example of teacher questions and student answers in one of the papers.

Assessment of the teaching intervention

Assessment by the students

A questionnaire was constructed in Google Drive and send to the students in order to assess the success (or lack thereof) of the teaching interventions from the students' perspectives. When writing this assignment, 11 out of 16 students have completed the questionnaire during the Christmas holidays.

1. Weekly assignment:
   Even though the introduction of the weekly assignment was rather vague, all the students were able to understand the purpose of the assignment and chose to complete the assignment in order to increase their learning outcome of the course (Figure 18.4A). The students were also eager to get an evaluation of their assignment and see how other students have solved the same assignment, as the students appreciate the time spend on evaluation of the weekly assignments (Figure 18.4B).

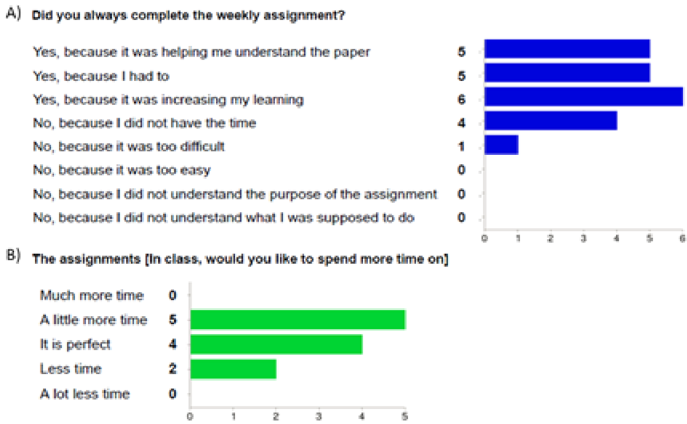

Fig. 18.4. Assessment of the weekly assignments

2. Embedded questions from the teachers:
   Much emphasis was put on this activity by the teachers and the students also find that the embedded questions from the teachers increase their learning outcome (Figure 18.5A) and they appreciate why it is important to answer the questions (Figure 18.5B) and realize the value of this:

   > "I think the questions are an essential part of understanding the paper, and they make me "dig in deeper" when reading and follow up on things which I am not completely sure about."

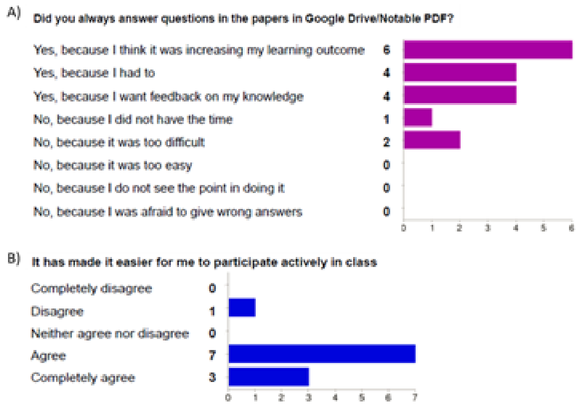

Fig. 18.5. Assessment of embedded questions from the teachers

3. Embedded questions from the teachers:
   Answers and questions from other students (Figure 18.6A, B) were very helpful for the students for increasing their learning outcome (Figure 18.6C).

   Overall the students would recommend the use of this online Google Drive/Notable PDF platform for a course with similar structure (18.7) and they appreciate the support it provides between classes, the possibility to work collaboratively and the increased learning outcome, when using this method. When asked “Would you recommend other courses with the same structure to use Notable PDF and collaborative annotation? Why? Why not?” students answered:

   > “Yes. It is helpful to keep students engaged in the class. People who don’t like to speak up in class can sort of speak up in notable PDF by asking or answering questions.”
   >
   > “YES! I think it works very well when we are working together to answer a question and can elaborate on answers already made. It is also a good way for the teachers to see what is going on during and maybe prepare something for the next lesson based on problems not answered by the students.”
   >
   > “Yes it’s very helpful when reading articles, because most

students have the same questions. Normally we more or less left to ourselves as students, so being able to use each other's knowledge helps a lot"

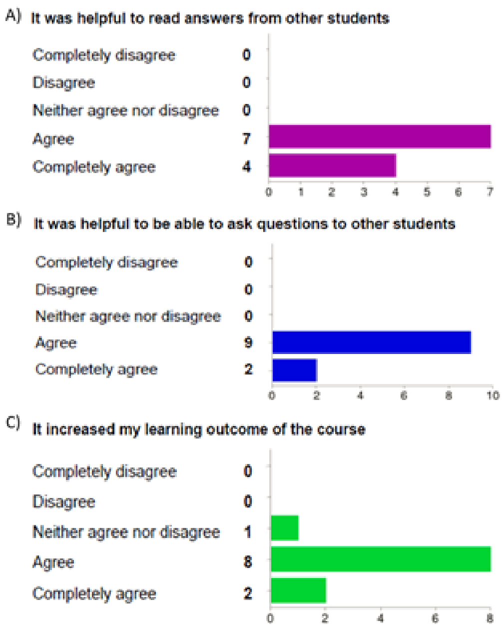

Fig. 18.6. Assessment of the use of collaborative annotation

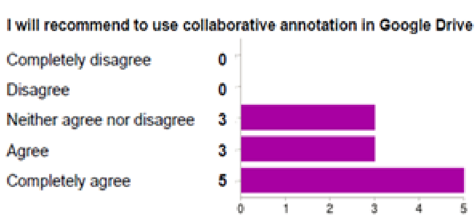

Fig. 18.7. Overall student assessment of collaborative annotation

Own assessment

Compared to last year when the course was running without the collaborative annotation platform the students seem to be more interested in class, they ask more questions and dare to ask about things they don't know. The intervention has given me a better feeling with the level of the students and it is easier to know how to use the limited time during class. Regarding the ILO's there is no formal assessment of the course at this point, and it is thus difficult to assess whether or not the teaching intervention has improved the learning outcomes - this will first be tested after another teaching module with the same set-up followed by a written assignment with an oral defense. However, very subjectively evaluated, the nature of the questions and the perceptiveness of the answers in class from the students seem to be on a higher level of understanding after this intervention.

1. Weekly assignment:
   The learning potential of the weekly assignment was not fully achieved during this intervention due to the lack of time at the end of the lessons where this section originally was placed. Moving the examination of the weekly assignments to the beginning of class has already improved the learning potential. However, the students express that they still learn from doing the weekly assignment even though we do not evaluate all of them in class. Furthermore, it has been hard to find the time for me to go through all the assignments before class and this part of class has thus been a little too spontaneous.
2. Questions from the teachers:
   First of all, making questions for the students has improved my own understanding of the papers and made me better prepared for class. It takes a long time to do this, but from the sometimes really great answers and all the positive statements from the students, I think the time is well spent. Fortunately, there is no doubt in my mind, that the learning potential of this part of the course is high and can still be expanded by using more time on facilitating and guiding the answers and discussions. The goal is to let the students answer, read each other's answers, reflect, and then maybe intervene in the discussion. It is rather difficult to know when to get involved as a teacher and there is probably no fixed model for this, since many scenarios are emerging asynchronously, such as:

> “The desirable”: The teacher asks a question - student answer – other students read the answer and agree - the teacher validate the answer.
>
> “The learning experience”: The teacher asks a question – students answer – other students read the answer, consider, investigate and write a clarification or correction – other students read this and agree – the teacher validate the discussion.
>
> “The unwanted”: The teacher asks a question – students answer – other students read the answer and agree - the teacher has to correct the answer.
>
> “The inevitable”: The teacher asks a question – no students answer – the teacher help with a hint – students answer – etc.

Of other considerations for increasing the learning potential of the teacher questions, I sometimes emphasize the outstanding answers by letting the particular student elaborate and explain to the other students in class and also I draw attention to the questions that are only partly answered or not answered at all and make the students collaboratively reach an answer in class by asking more or less suggestive questions.

3. Online collaborative platform between classes: The possibility to ask questions from student to student or student to teacher outside the teaching hours seems to be very helpful for the students. They find assurance in this feature and do not feel left all alone. As a teacher it is very helpful for see these questions, which many students might not dare to ask during class, and it is very satisfying to see other students give an answer before I manage to do so. This is freeing up time, from questions only one or two students struggle with, to spend time on problems that are more general for the whole class. The possibility to read each other’s answers to teacher or students questions seems to benefit the learning experience for the students, firstly because they do not have to look up everything they do not know for every paper (and that is a lot!), but can rely on other students answers. And secondly, they learn from taking the responsibility of formulating a precise answer that other students will read.

   Again, the learning potential of this part might be expanded by encouraging students to participate more in this activity and by increased teacher activity to facilitate discussions and curiosity.

In conclusion, introduction of methods to constructively align ILOs and TLAs as presented here has improved the learning outcome from both the student's and the teacher's point of view.

Acknowledgements

I would like to thank Kirstine Dahl and Michael Drastrup for pedagogical guidance throughout this work.

19

Applying real life examples for improved learning outcomes

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Aim

The aim of this project was to redesign and optimize a classroom lesson within the course "Drug Formulation" for BSc students in pharmacy by applying a 'problem to solve' teaching style in order to improve the students ability to apply and crosslink their knowledge about pharmaceutical formulations, i.e. support deeper learning and understanding rather than memory.

Background

Pharmacy is a study program that educates students towards professionals to deal with the scientific and social challenges around medication today and in the future. It is divided in several different subjects that are taught in parallel, just as the course "Drug Formulation", in which I am teaching one classroom lesson four times each to a reduced student size of approx. 10 students.

The course "Drug Formulations" is placed in the 5th semester and is divided into 27 auditorium lectures and 15 classroom lessons taught by numerous teachers that are responsible for their parts of the course. The intended learning objectives (ILOs) cover a broad range of topics within pharmaceutical technology including physico-chemical and biopharmaceutical properties of drugs, excipients in drug formulations, as well as the influence of the drug delivery system on bioavailability. The course "Drug Formulation" gives the students the theoretical background for their bachelor project in the 6th semester and provides the fundamental basis for subsequent courses in the MSc in Pharmaceutical Sciences. Thus, it is of crucial importance that BSc students early on obtain basic understanding and essential knowledge in this field of study.

According to (Biggs & Tang 2011*b*, p. 91-94), there are two kinds of knowledge that can be taught. Declarative knowledge is pure knowledge that is memorized, e.g. knowledge that can be found in books, libraries etc. *Functional knowledge* on the other hand is performing understanding of the pre-received knowledge. It is 'real' understanding of concepts and being able to interact thoughtfully with the knowledge to solve a professional problem or manage a task. In order to obtain a 'professional' knowledge, both forms are complimentary as deep understanding of theory and application is the bases of functional knowlegde.

Within the course "Drug Formulations", the auditorium lectures are intended to provide the declarative knowledge, whereas the classroom lessons try to introduce some functional knowledge on particular examples. The classroom lessons deal with an assignment comprising a set of questions in order to show the students how *one* specific drug is formulated into its drug formulation. For this purpose, the students get the assignments beforehand and relevant literature references, which is the basis of their preparation for the classroom lesson.

I took over the one of the classroom lessons in 2013, which means that in this project it is the second time I am teaching it. In the first round, I also took over the "old-fashioned" set up of how the class used to be taught. The students were divided in small groups (3-4 students) in the beginning, in which they were able to discuss each question for a short time using the information from the supplied literature and their theoretical background from the auditorium lectures. Afterwards their findings were evaluated briefly in the whole class before moving on to the next question in a similar fashion. My task as a teacher was to guide the students through the question and help them where needed to find the right answer to the respective task. When taking over the class and teaching style, I quickly discovered that the assignment merely gave the impression that 'finding the answer to a question' is the key to knowledge rather than why is this knowledge important and what can it be used for. Therefore, I found that the 'old system' showed some obvious drawbacks, e.g.:

- Students that did not prepare for the lesson usually did not participate in the discussions, but rather where there to be taught the answers to the question.
- In the evaluation phase, usually only individual students from each group contirbuted to the discussion, whereas the rest of the group remained silent.
- Students that were well prepared and already solved most of the tasks at home were not interested in seeing a repetition of what they did at home.
- The ‘find the answer’ model does not promote deep learning or create functional knowledge, as it does not put the knowledge into relevant context.
- Students might perceive the knowledge as irrelevant which enforces surface learning.

Going back to the overall ILOs, the students are supposed to gain a big background knowledge on the basic theory, techniques and methods behind drug formulations, and furthermore obtain deeper understanding on how to correlate this knowledge to unknown scenarios. Generally, these ILO’s are also in line of what I expect from the students passing this course. Especially with respect to declarative knowledge, the ILOs are also met to a high degree. However, in my experience from teaching in the Bachelor project (6^{th} semester), where students get an individually assigned task to solve on their own, the functional knowledge has not been previously obtained. It appears that during their BSc project, it is the first time that the students are confronted with real life situations and that they have to deal with problems that requires them to apply and cross-link their knowledge in a functional way. It is obvious that the current model of the course is not entirely optimal because students did not learn the required skills for a self-driven BSc project beforehand. I certainly believe that these skills are of crucial importance and should be and can be fostered early on already during the course “Drug Fromulation” in the 5^{th} semester. Students need to face problem situations and need to reflect and interact actively with these situations in order to enforce deep learning. These can be introduced for example in the classroom lessons.

Strategy and Methods

Rather than guiding the students through a set of questions related on a very theoretical basis in a 'finding-the-answer' fashion, one could set the assignment into a relevant context and let the students deal with a 'problem-to-solve' task. The students would learn to actively use their theoretical background in order to solve the problems. Compared to the 'find-the-answer' approach, I strongly believe that the 'problem to-solve' approach will improve the students' ability to apply their knowledge. Therefore, the aim of my project is to use this approach to my classroom teaching.

This concept is part of the theory of didactic situations (TDS) (Christiansen & Olsen 2006). TDS means creating meaningful examples that the students might actually be confronted with in their future professional life. This will catch the interest of the students and makes them aware of the importance of the subject. The term for creating such an artifical scenario in a lesson is called a 'didactic environment'. There are two things to consider. First the knowledge that is needed to solve the tasks in the assignment needs to be personalised. A situation needs to be created that is relevant to the students personal experience and knowledge, in order for them to adapt to the environment. And second, the knowledge the students learn needs to be (re)discovered, i.e. based on the student's own construction.

When planing the redesign of the lesson, I started to go through the written assignment and the material intended for preparation at home. Since the material was already handed over to the students at the start of the semester, I was not able to modify the written assignment. Fortunately, the assignment itself was written in a way that it actually could be used in the 'problem-to-solve' teaching style. The only downside of the assignment was that it did not reveal the relevance of the knowledge behind each question with respect to pharmaceutical formulations. Therefore, it was setting the assignment into the right context, i.e. change the way I used to teach it. However, not changing the assignment was in fact beneficial, as I was now able to run the old 'find-the-answer' teaching style in a comparative experiment with the 'problem-to-solve' approach. As mentioned above, I was teaching the same classroom lesson four times to a reduced number of approx. 10 students. Thus, I decided to teach one of the lessons in the old 'find-the-answer' fashion and compare it to three lessons applying the new 'problem-to-solve' approach.

The next step then, was to create a realistic and meaningful didactic environment that the students can relate to. Therefore, I decided to tell the students in the beginning of the lesson that we will play a little mind game where they are now part of a pharmaceutical company that recently developed a new drug (in my case morphine). They are employed as pharmaceutical scientists and were asked to formulate this drug and all they got is the information from the preparation material. What information is important and what do they have to consider in order to end up with a successful pharmaceutical product? Therefore, the scene of the lessons in the ’problem-to-solve’ approach was according to the principle: If the aim is to make a pharmaceutical formulation with morphin, then making the formulation from scratch is the obvious teaching/learning activity, under the appropriate didactic environment in the classroom lesson (Biggs & Tang 2011*b*, p. 179).

Finally, I modified the teaching style. Even though the old style had some pedagogic parts I liked, e.g. the group work, I was not entirely happy with the current setup, e.g. the drawbacks listed above. Therefore, I changed it to a ‘lively and open’ discussion amongst the *whole* class. I wanted to achieve that *all* the students are part of the developing discussion. All the students need to be part of the process where they rediscover their knowledge, i.e. the relevance behind the each question for the final formulation. Since I was afraid that the developing discussion would cease when debating each question one by one, I also decided to let go from this apporach. Instead, the evolving discussion will supply them with the answers to each specific question along the way as the knowledge behind it is interconnected.

My role in the lesson was to guide the students through the discussion, keeping it alive, and keeping them on track, so that they do not drift to far away from the assignment. Thereby, I was able to adjust each discussion according to the needs among the students. Depending on which points the students raised, different pathways towards the answers could be followed. For this purpose, I wrote a ‘manuscript’ with potential questions from my end to keep the discussion active (Appendix A). Before I gave the first lesson I studied this manuscript.

In order to assess the lessons, I handed out a class assessment form (Appendix B), where the students were able to evaluate the classroom lesson and its format, but also write down their perception of their learning. The assessment form was divided into a quantitative (Appendix B, points 1-4) and qualitative part (points 5-7). Furthermore, I was talking to individual students afterwards in order to get a more personal feedback.

Assessment

All four lessons ran very smoothly and I perceived the students activity and interest in the lesson as generally similar and positive. This was also reflected in the feedback from the student assessment form (Appendix C). Applying either teaching style, the students found the lessons to be similar in diversity, niveau, exam relevance and clarity of the ILOs. Furthermore, the students were well prepared and according to their own estimation learned new knowledge to a similar degree (4.6 out of 6 in both teaching styles). This was expected to some degree as my clear aim in teaching both styles was to fullfill the same ILOs.

The evaluation of the assessment form however, revealed also some differences such as in the students perception of the lesson. The 'problem-to-solve' approach was perceived much more interesting (5.5 out of 6) compared to the 'find-the-answer' approach (4.7). This was not surprising as it was my intention to increase the students interest in the subject by applying TDS. It was further confirmed when aksing individual students after the lesson about how they think this teaching style was and how it was compared to other classroom lessons. It became obvious that the 'answer-the-question' approach was what they expected from a classroom lesson as it was "Compareable to other klassetimer". On the other hand, the 'problem-to-solve' approach resulted in a much more positive feedback:

- "It was really funny and easy to follow"
- "Actually, I prefer this way of teaching, it gives more relevance to the subject"

Furthermore, the students own impresson of how much they actively contributed to solve the tasks in the lesson was different in both systems. It appeared that the students thought to be less active in the 'problem-to-solve' teaching style (3.9 out of 6 compared to 4.4). This might be explainable by the new teaching style. An open discussion in the whole class could scare 'shy' students or students that are not very well prepared from participating actively in the dialogue. Especially shy students rather work in smaller groups with their 'friends' where they dare to share their opinion. Furthermore, the risk with such an approach is that a few very motivated might run the show, giving no time or space for the more quiet students to contribute. When changing the teaching style, I was aware of this problem and thus, tried to activate the more quiet students throughout the lesson and involve them in the process. Thus, the result turned out to be still very positive (3.9) in the 'problem-to-solve' approach, but leaves space for improvement. When interviewing some individuals after the lessons, they also pointed towards the involvement of quiet students in the discussion:

- "Group discussions in some cases would be good. Then the silence of some students might disappear"
- "It would be good to place the students closer to each other in the classroom so that it is easier to discuss with them and keep them active"

Part of the qualitative assessment was to observe whether the students have learned something in the lessons (Appendix B, point 5). The answers written for both teaching styles covered a wide spectrum of what was mentioned in the lesson but mainly in very broad terms. There was no description of the theories or knowledge behind these terms. Thus, it was difficult for me to evaluate these and draw a reasonable conclusion. However, it was interesting to read that students supplied very different subtopics of the lesson, meaning that a broad area was covered. In a future assessment form, I would modify point 5 to a more concrete task that can better be evaluated.

The students were moreover asked to mention those things that were best and worst in the assignment (Appendix B, point 6 and 7). The supplied responses gave a very interesting but also motivating and confirmative result. Thus, the feedback in the 'find-the-answer' lesson was very reserved and concentrated on the structure and content of the lesson:

- "Clear and structured way through the questions"
- "To think more in a chemical way"
- "I didn't know more to begin with when I came"

It was clear that the students had not much to add to a system they were used to, but they valued the structure of the lesson as it sticks close to the assignment. Furthermore, students seemed to have perceived the assignment as pure repetition from the declarative knowledge they get from the lectures and thus, found it less interesting.

On the other hand, there was an extensive feedback from the students taught in the 'problem-to-solve' style. This might be due to the fact that the students were facing a new way of teaching. Generally, they found the 'problem-to-solve' approach very interesting, but also wrote that they learned a lot of new things. It was obvious that the students were very glad that they were able to apply their knowledge to a relevant situation:

- "Many good facts, learned a lot"
- "The opportunity to discuss in class"

- “You better learn a system when you actually use it”
- “The teacher was very active, and this caught our attention”
- “That we were able to explore a drug molecule and decide ourselves how we would formulate it”
- “The flow in the dialog in which the assignment was performed, and not the slavery like way through the single questions”
- “That we were challanged”

Overall, I got the impression that the students were pleased by the open discussion and the freedom to decide (with some guidance from my end). This was reflected in a very lively dialog in these lessons, that most of the students participated in. From the feedback, I conclude that it is very likely that my aim of getting the students to rediscover their pre-existing knowledge was successful.

Despite the positive feedback, the ‘problem-to-solve’ lesson demonstrated one drawback. With the very open setup and dynamic flow, the students found it really hard to follow the questions in the assignment. It was hard for them to understand why the questions were given beforehand. The whole lesson was perceived a bit confusing as the answers were not supplied in the chronological order but rather as a result of the progressing discussion. Accordingly, it was mentioned in the assessment form but also during the student interviews. I suspected such criticism as I was unable to change the written assignment beforehand. Thus, my aim is to address this issue by redesigning the assignment in the future.

Overall, I want to finish with a quote from an interviewed student that summarizes the ‘problem-to-solve’ teaching style with its ups and downs, but pointing out the potential as a continuing teaching style in the classroom lessons of the course ‘Drug Formulation’: “It wasn’t easy to follow where we were in the questions, but it was very interesting and had a dynamic flow”.

Conclusion

In this project I have redesigned the teaching style of a classroom lesson applying TDS in order to increase deeper learning and create functional knowledge. My aim was that the students learn the concept, methods and principles of formulating a drug in the context of a ’realistic’ didactic environment. I found it interesting to apply a (for me) new teaching style and compare it to the one I previously used. I realized that reflecting over ones own teaching can introduce some very rewarding new elements and improve my teaching skills but also motivate students. I found that the redesigned course got a very motivating feedback, as students were very positive about being challenged in a way they experience their knowledge as meaningful. However, the students criticized that it was hard to follow the questions from the assignment. It can be concluded that applying TDS was beneficial for the students to adapt functional knowledge in the context of this classroom lesson.

Perspective

It was found that the teaching style was not aligned with the written assignment the student got beforehand. Obviously, this needs to be addressed in future as I am planing to keep the ‘problem-to-solve’ approach in my classroom lesson. Furthermore, it was pointed out that students do value work in small groups to some degree. Therefore, I would like to introduce group work again at relevant points of the discussion. This would also force more students into the discussion and thus, increase the students activity. For a better assessment, it would be good to get more actual student performance data (Appendix B, point 5), whether the lesson actually resulted in better learning outcomes.

A Manuscript for the 'problem-to-solve' lesson

1. Morphin
   - What pharmacological class of drug does it belong to?
   - What is its indication?
   - Strong pain, weak pain?
   - How would you according to its indication deliver it?
2. You are now working in a pharmaceutical company and are asked to make an as fast as possible oral delivery of the drug.
   - What do you need to consider first? → physico chemical properties
   - What are these properties and how are they defined?
3. Why are these relevant? because they influence the bioavailability
   - What is bioavailability?
   - What does Lipinskis rule of 5 tell us?
   - How is the BCS classification system defined and what does it tell us?
   - How does the phys-chem data of morphin help us to classify the drug? [→] Can be classified as BCS class 1 drug, i.e. high solubility and permeability
4. However, its oral bioavailability of Morphin is 20-40%
   - How can this low bioavailability be explained? Metabolism
   - What types of metabolism do you know?
   - Where does metabolism happen?
   - What is the reason for metabolism?
   - Which ways of excretion are possible?
5. How does metabolisation work
   - What chemical reactions can happen during metabolism?
   - How can a molecule be modified to prevent metabolism?
6. In a formulation morphin might also undergo degradation
   - What types of degradation do you know?
   - How can you prevent the molecule from degradation in your formulation?
   - What excipients can you include for this purpose in you formulation
7. We have the drug, prevented oxidation with an antioxidans, EDTA and nitrogen
   - What else do we need for an oral formulation?
   - What else do we need to consider in case of an intraveneous formulation?
   - What excipients can we use for these purposes?

B Class assessment form

1. How did you receive the Klassetime?

	1	2	3	4	5	6	
Unclear Learning objective	o	o	o	o	o	o	Clear learning objective
Monoton	o	o	o	o	o	o	Diverse
Too low niveau	o	o	o	o	o	o	Too high niveau
Not relevant	o	o	o	o	o	o	Exam relevant
Boring	o	o	o	o	o	o	Interesting

2. How much did you learn today?

	1	2	3	4	5	6	
Only little	o	o	o	o	o	o	Quite a lot

3. I tried actively to solve the tasks the teacher asked me to do

	1	2	3	4	5	6	
To low degree	o	o	o	o	o	o	To a high degree

4. How was your preparation for today's klassetime?

	1	2	3	4	5	6	
Unprepared	o	o	o	o	o	o	Well prepared

5. Name at least two things you learned in the klassetime today:

____

____

____

6. What was best in the assignment?

____

____

____

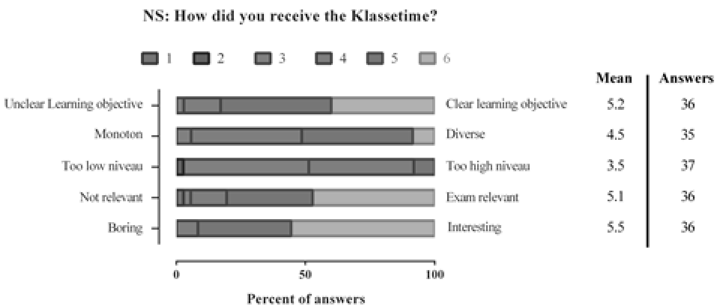
7. What was worst in the assignment?

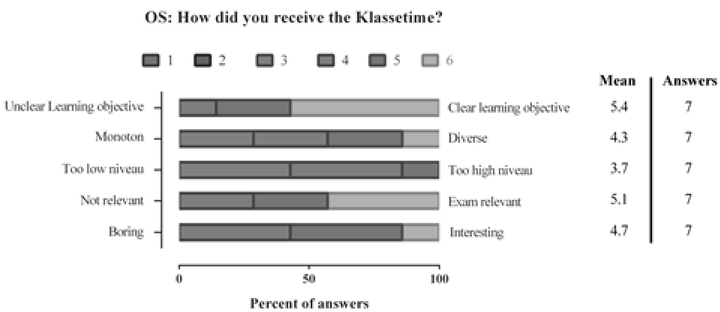
____

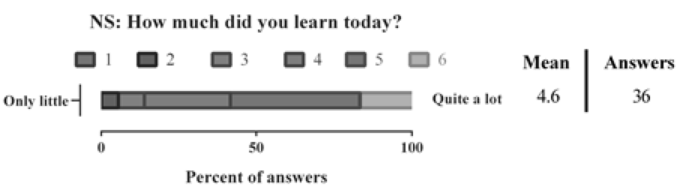
____

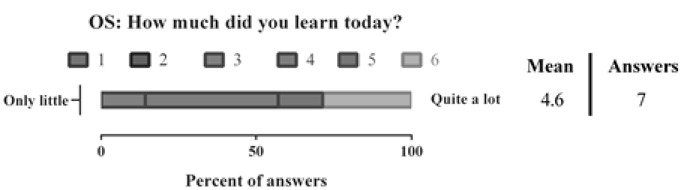
____

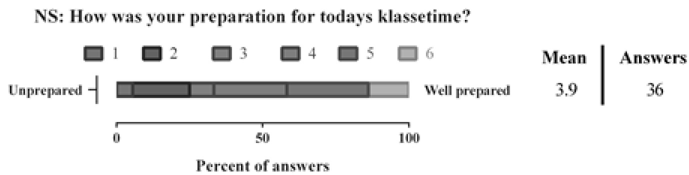
C Quantitative evaluation of the class assessment form (NS: new system, OS: old system)

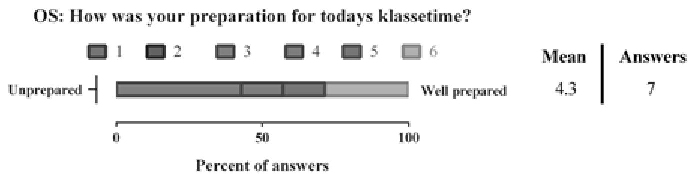


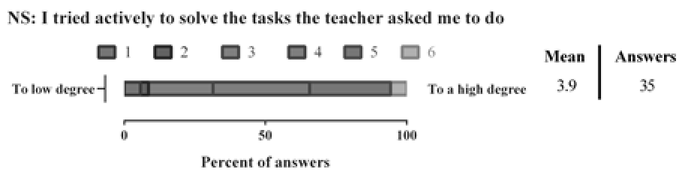


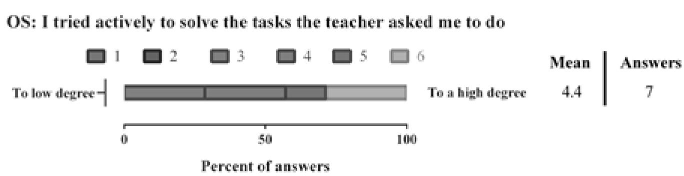





NS: How was your preparation for todays klassetime?
1 2 3 4 5 6
Unprepared
Well prepared
Mean
3.9
Answers
36
0 50 100
Percent of answers


OS: How was your preparation for todays klassetime?
1 2 3 4 5 6
Unprepared
Well prepared
Mean
4.3
Answers
7
0 50 100
Percent of answers


NS: I tried actively to solve the tasks the teacher asked me to do
1 2 3 4 5 6
To low degree
To a high degree
Mean
3.9
Answers
35
0 50 100
Percent of answers


OS: I tried actively to solve the tasks the teacher asked me to do
1 2 3 4 5 6
To low degree
To a high degree
Mean
4.4
Answers
7
0 50 100
Percent of answers

20

Balancing passive and active learning

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Introduction

Active learning is often encouraged in tertiary education management and pedagogical training (Biggs & Tang 2011*a*). Active learning is often resisted by those that educate at a tertiary level. The resistance is typically expressed informally (Biggs 1981). Reasons for resistance are typically not published as such in journals of higher education; resistance is not based upon an extensive critique of active learning as a clearly defined target; nor is it based upon a defence of a clearly defined alternative, which one might call ‘passive learning’. For the purposes of discussion, passive learning can be defined as any activity that does not involve going beyond those activities central to the reception of a traditional lecture. Activities central to the reception of a traditional lecture are those such as “simply watching, listening and taking notes” (Felder & Brent 2009, p. 2). An active learning teaching strategy can then be defined as any teaching strategy that introduces activities that go beyond those central to the reception of a traditional lecture. Active learning strategies are compatible with passive learning strategies, but can also transcend the traditional lecture by “introducing activities into the traditional lecture and promoting student engagement” (Prince 2004, p. 225).

Plausibly, a typical teaching strategy for a given session will exist on a continuum between extremes of active and passive learning (Bonwell & Eison 1991). Placement of a teaching strategy on the continuum can be seen as a function of the extent to which it departs from or adheres to the promotion of activities central to the reception of a traditional lecture. There are perhaps only few cases at the extremes. But it may well be that worries about an active learning teaching strategy at the extreme forms the basis for resistance to active learning in general. This extreme is 'discovery learning', "in which students are expected to work in groups in a learning environment with little or no guidance" (Mayer 2004, p. 14). As Mayer puts it: "Pure discovery—even when it involves lots of hands-on activity and large amounts of group discussion— may fail to promote [selection of] relevant incoming information" (ibid., p.17). This suggests some degree of motivation for guided instruction, even in the context of relatively free active learning strategies, in order to facilitate selection of relevant information. Thus we might conceive of passive learning strategies, at the extreme, as involving maximal selection of information by the teacher – call this 'guidance' - and active learning strategies, at the extreme, as involving minimal selection of information by the teacher – call this 'discovery'.

Finding the right balance between guidance and discovery is the challenge that motivates this project. In what follows, I will compare two ways of balancing guidance and discovery in the context of two modules of two distinct MA programmes at the University of Copenhagen. In one module, a fairly fixed balance between guidance and discovery persisted throughout the course of teaching. Call this 'Balance 1'. In another module, there was a gradual shift from passive to active learning strategies during the course of teaching. Call this 'Balance 2'.

In section 2, I will further describe the two MA modules, to give a sense of the context and content of the teaching. In section 3, I will describe the teaching strategies involved in the two modules with respect to the ways in which a balance between guidance and discovery was employed during the course of the teaching. I will also discuss the strengths and weaknesses of each balance. In section 4, I will discuss some of the ways in which each balance seemed appropriate to the particular constraints imposed by the module in which it was employed.

The modules

Balance 1 was employed in a module of the University of Copenhagen's Philosophy MA programme, titled 'Central Topics in Phenomenology and Philosophy of Mind' (hereafter 'CT'). Balance 2 was employed in a module of the University of Copenhagen's Cognition and Communication MA, titled 'Embodied & Embedded Cognition' (hereafter E&E). The two modules had some overlap in content. In this respect they were similar. But they were very different both with respect to the MA programmes of which they were part and the disciplinary background of the students in attendance.

Central topics in Phenomenology and Philosophy of Mind

The Philosophy MA programme at the University of Copenhagen aims to advance the kinds of philosophical skills and knowledge that one might obtain in BA degree. Modules cover a range of traditional subjects in the major areas of academic philosophy: ethics, metaethics, applied ethics, political philosophy, aesthetics, epistemology, metaphysics, philosophy of science, logic and philosophy of language, and Ancient, Medieval, Renaissance and Early Modern Phenomenology and analytical philosophy of mind are two of the most influential approaches to the theoretical study of mind in the 20th century. The two traditions have significant overlap in subject matter, specifically regarding topics such as the nature of intentionality, self-consciousness, subjectivity, embodiment and social cognition. But each tradition has been developed in relative isolation from the other, and to the extent to which there have been interactions between proponents of each tradition, these interactions have often been marked by hostility and ignorance[1].

CT aims to develop the ability to critically engage with texts from both phenomenology and analytical philosophy of mind. The course material is presented with a view to discerning the ways in which the central concerns of both traditions are similar, yet distinct and perhaps complementary. The module also aims to develop students' understanding of how the two traditions might fruitfully interact in advancing contemporary discussions in philosophical psychology. The intended result is to show how the combination of both phenomenological and analytical approaches to the mind may provide increased theoretical sophistication to empirical cognitive scientific research.

The content is divided into three sequentially ordered sections: 1) intentionality and consciousness, 2) embodiment, and 3) social cognition. The material is orientated towards philosophical psychology in sections 2 and 3. Each section is taught by a separate teacher. I taught the second section, titled 'embodiment'. This section comprised four teaching sessions. Two

[1] For exceptions see Gallagher & Zahavi (2008) and many of the contributions to Smith & Thomasson (2005).

of these sessions concerned the ‘Extended Mind Thesis’, the thesis that the material bases of mental states can in some cases extend beyond the brain and include aspects of the body and environment (Clark & Chalmers 1998). This philosophical thesis has been developed and discussed in the context of a broader movement within cognitive science more generally, known as ‘Embodied and Embedded Cognitive Science’ (Shapiro 2010). In this part of the module, three of the four readings assigned were identical to those assigned and recommended for sessions of the module E&E in the Cognition and Communication MA programme.

E&E

The Cognition and Communication MA programme is hosted by the Department of Media, Cognition and Communication. It is taught by individuals in the Philosophy Section of the Department (including myself) and individuals in the Film, Media & Communication Section. It is explicitly interdisciplinary in scope. It offers modules covering qualitative research methods, media science, human computer interaction, communication theory, film theory, philosophy of science and cognitive science. The latter is itself an interdisciplinary field including aspects of philosophy, psychology, artificial intelligence, neuroscience, linguistics and anthropology.

The aim of the Cognition and Communication programme is to give students a strong theoretical basis for practical endeavours that may benefit from any of the various possible combinations of the disciplines involved in the programme. The panoptic scope of the programme allows the student to develop a fairly unique line of study to develop specific expertise in a variety of fields. Students are also encouraged to replace elective studies with an internship to explore the potential for combining theory and practice.

E&E is the second of two modules focussed on cognitive science. The first is an introductory module in the first semester, appropriately titled Introduction to Cognitive Science. Assuming this introduction as a basis, E&E surveys several recent developments in cognitive science that are unified in their rejection of what is known as Classical Cognitive Science. The module thus involves a detailed discussion of the central theoretical elements of Classical Cognitive Science that the movement rejects, as well as assessment of the theoretical significance of the shift in focus that characterises recent ’embodied’, ’embedded’, ’situated’, ’enactive’ and ’extended’ theories of cognition. These theories variously shift the focus of cognitive scientific methodology and explanation to the ways in which the bodily structure and environmental situation of cognitive agents putatively shape and even constitute cognitive activity. In large part, the motivation for this shift is conceptual. Cognitive systems and cognitive processes are conceived as potentially consisting in non-neural material structures and processes. In this respect, the module differs significantly from other aspects of the programme, especially the various more practically orientated aspects, as it covers a range of issues concerning the nature of cognitive systems and the theoretical, methodological and philosophical foundations of cognitive science.

Two ways of balancing guidance and discovery

Balance 1

The session format in CT remained relatively fixed throughout the semester. Each session included prepared lecture material presented by the teacher and two individual presentations by two students attending the module. The only exceptions to this were the first session, in which no students presented, in order to allow sufficient time to given an adequate introduction to the course, and one of the later sessions, in which one of the students was unable to present due to personal injury.

In the sessions that I taught, the prepared lecture material would elaborate on the issues motivating the readings assigned and the broader context of the topic in question. PowerPoint presentations were always used. These tended to have very little text; they typically would require the associated commentary and some familiarity with the subject of discussion, in order to be fully intelligible. Two or three short lectures would be broken up into twenty or thirty minute sessions, each would end with discussion questions to be addressed in plenum following a break. Students were required to give a presentation of fifteen minutes on one of the two readings assigned for the session. Each presentation was followed by a discussion directly afterward. Students were encouraged to provide an exposition of the main arguments of the text assigned, to assess whether and if so the extent to which the author's arguments were successful, and the ways in which they might be further criticised or improved. Students were also encouraged to use their presentations as the basis for their examination, which consisted of a written assignment of no more than ten pages and a half-hour oral examination.

The strengths and weaknesses of Balance 1

Strengths

Balance 1 provided a highly regular structure to each teaching session. It enabled both focussed discussion of the particular class readings (through the student presentations) and more general discussion of the broader issues (through the teacher presentations). The relatively strict constraints on the content of the presentations ensured that when students actively engaged with the course material they did so in a manner that remained focussed on relevant issues. It also served as an effective means of covering large amounts of course material. Finally, encouraging students to use their presentations as the basis for their examination perhaps partially explains the high success rate in getting attendees to take an examination for the module, something that has been an issue across the Philosophy MA programme and in previous years in which the module was offered.

Weaknesses

The quality of student presentations can vary significantly. This can result in having to spend discussion time and even lecture time on carefully clarifying the issues and addressing misunderstandings. Depending on students to articulate the content of the readings can also be an issue in cases where students decide to give a more independent presentation. Even if this is not necessarily a poor presentation, it can result in poor integration between teacher and student presentations. On the other hand, it ought to be noted that limiting student presentations to the assigned readings does place fairly strict limits on creative insight. Indeed, one ought to be wary of the assumption of optimal selection of material for the students' learning of the subject matter. It may well be that a more independent presentation from a capable student, able to engage effectively with a slightly broader range of literature, would provide greater insight and more lasting understanding. Moreover, having student presentations as the only active learning strategy may be imprudent, given that certain students may benefit from the presentations less than others. Finally, though the format does promote some student interaction, the interaction is somewhat limited, relative to that involved in other active learning strategies.

Balance 2

The session format in E&E varied considerably, though systematically, through the course of the semester.

Sessions in the first third of the course consisted mostly of teacher presentations interspersed with teacher student discussions. These were of the typical kind for a standard lecture, in some cases involving the student interrogating the teacher and in some cases the teacher interrogating the students. Two sessions were taught by a guest lecturer, an expert on cognitive anthropology, and followed a similar learning strategy. Sessions in the second third of the course involved considerably less lecturing, with the majority of the session devoted to student activities. All of these activities were combined with lectures. These activities included: discussion in pairs, followed by discussion in plenum; discussion in three to four person groups, followed by discussion in plenum; discussion in larger groups, with the attendees split into two groups, followed by a debate between the two groups.

Sessions in the final third of the course were almost entirely devoid of lecturing. Activities included: attendance of the conference “Thinking (about) groups”; field-trip to the Helene Elsass Center (HEC); student PowerPoint presentations; one-on-one teacher-student discussion prior to presentations and after submission of a term paper draft; discussion of term paper drafts in three to four person groups. I will say a bit more about each of these before moving on.

The “Thinking (about) groups” conference was held at the University of Copenhagen from the 8th to the 10th of October[2]. Students were told to attend at least three of the sessions of the conference and write up their impressions. In particular, they were told to try and relate the discussion to topics and themes that had piqued their interest during their studies.

The field trip to HEC was run by Kristian Moltke Martiny, a postdoc at the Center for Subjectivity Research[3]. Kristian gave the students a tour of the HEC rehabilitation programme followed by a lecture on how embodied and embedded cognitive scientific research might be applied for the development of rehabilitation strategies and technologies for people with brain damage.

Students were told that the aims of the student presentations were to bring together a set of ideas and literature on which they would like to

[2] See http://cfs.ku.dk/calendar-main/2014/thinking-about-groups/

[3] See http://elsasscenter.dk/ and http://cfs.ku.dk/

write a term paper and to make the first attempt at outlining the structure and content of their term paper. They were also told that the length of the presentation should be no longer than twenty minutes, leaving a further fifteen minutes for discussion.

One-on-one discussions were held in my office on each day prior to the presentations. I met each student for an hour. Students were encouraged to send any material that they had for the presentation prior to the meeting, but were also told that this was not necessary. I began each discussion by asking the student what they found most interesting about their topic and what they had read concerning their topic. I then lead the discussion towards their presentation, giving advice for how to best present their ideas, going through slides if available. Finally, we would discuss how best to structure their term paper.

The final session of the module took place in the week after students were encouraged to submit an up to five page draft of their term paper. I met any student that had submitted a draft for half an hour to discuss how it could be developed and improved. I used the draft material to develop a brief presentation of common issues faced in preparing a term paper for the course. After this presentation, students discussed their term paper drafts with one another in three to four person groups, taking turns to answer the following series of questions: What's the main issue? How is it, or how might it be, theoretically motivated? What's the most relevant article/chapter (or set thereof)? What's the main argument/point of contention there? How are you structuring your paper? How, if at all, does the structure aid your critical evaluation? What (if anything) do you feel that you have well covered? What (if anything) are you struggling with, and why?

The strengths and weaknesses of Balance 2

Strengths

The major strength of Balance 2 is that the course of the teaching incorporates a variety of teaching styles and learning strategies. This serves well to overcome a weakness of Balance 1 in this regard. The debate activity is noteworthy for its success and the ease with which it can be combined with traditional lecturing. There are in fact many ways of varying this kind of activity to tailor it best to the individual class (Kennedy 2007). I chose to have the debate follow two short lectures in which I had presented the main arguments for and against a controversial thesis. The debate fostered a good discussion environment both in the individual session, but also in future sessions, with students becoming more ready to address one another's remarks in a friendly, yet critical manner. The variety of student activities also matched well with the nature of the MA programme and expectation that students will follow a fairly independent path through the various opportunities for learning disciplinary expertise and combining theory and practice. Informal discussion with the students gave the impression that the field trip and the conference attendance was also very useful in this regard.

Finally, having fairly independent student presentations addresses certain worries with the strict constraints on student presentation in Balance 1.

Weaknesses

The lack of uniform structure to the teaching sessions that Balance 2 requires results in a much less orderly course of teaching than Balance 1, which in turn requires much more frequent communication about the structure of each session. The third part of the course, devoted almost entirely to student activities, requires less preparation of lecture material, but it is in fact far more time intensive as it presents the teacher with a significant administrative workload. In addition is the extra reading, writing and interaction time involved in the one-on-one interactions. Arguably these are indispensable, at least if one is to give sufficient guidance to the students such that they do not lapse into pure discovery learning. Poor presentations can be avoided to some extent by meeting students beforehand. But this does not necessarily ensure that the student will be adequately prepared or able to present their ideas in a timely and reasonably engaging fashion. Given that entire sessions were dedicated to student presentations, the opportunities for addressing misunderstandings were fewer than in Balance 1. Also, devoting entire sessions to presentations created the further problem of a gradual decrease in student attendance, where many of those that had presented in previous sessions did not attend later sessions. Finally, giving over so much of the time to student activities, especially independent student activities, had the inevitable consequence of reducing the amount of material that could be covered.

Finding the right balance for the learning situation

Despite the weaknesses discussed, there are various reasons to think that the balance chosen for each module was more appropriate for the module than the balance chosen for the other, given the unique features of each course of teaching. Specifically, there are three ways in which the course of teaching differed between the modules, which each seem relevant when considering which balance of guidance and discovery is most appropriate.

Disciplinary uniformity

The nature of the Philosophy MA in general and the Phenomenology and Philosophy of Mind Specialisation in particular is such that it attracts applicants with a strong background in academic philosophy. As a consequence, the disciplinary expertise of the student body was expectedly uniform; almost all students had some experience in studying philosophy academically and most had a previous full degree in the subject. By contrast, the explicitly interdisciplinary nature of the Cognition and Communication MA is such that it attracts students from a range of disciplines. The range of disciplinary expertise in the student body for the 2014 E&E module covered Journalism, Semiotics, Political Science, Sociology, Anthropology, Cognitive Science, Psychology and Philosophy. For such a mixed group, a gradual shift from precise (but less interactive) lecturing to highly interactive (but less precise) student activities is plausibly much more beneficial. Whilst the lectures provide a common ground for the diverse group, the interactions allow the group members to take advantage of their individual differences in expertise.

Variety of teachers

E&E is typically taught by one teacher. By contrast, CT is typically taught by three teachers, one for each section (intentionality and consciousness; embodiment; social cognition). This situation makes Balance 2 rather difficult to implement in such a course. Firstly, the subject matter would covary with changes in format, but for no good reason. Secondly, the differences in teaching style between the teachers would be combined with the differences in format, but not as a matter of the teacher's own preference. Both of these are likely to increase a sense of overall disorganisation in the course of teaching. Thirdly, the administrative load and time demands upon the third teacher will be much greater than the first two.

Nature of examination

Although in both modules students were encouraged to focus their examination upon the subject of their presentations, the two modules differed significantly in the forms of examination that students were typically required to take. In CT, students were required to submit an essay of up to ten pages, which would serve as a basis for an oral examination that would also test their knowledge of other aspects of the course material. Accordingly, restraining the student presentations to the course material provides some degree of uniformity to the written and oral examinations. By contrast, E&E is examined by a 20 page essay alone. Combining a more independent presentation with plenty of individual discussions between students and between students and teacher seems more appropriate for the development of thought required for a longer paper.

21

Evaluation of continuous formative assessment during lectures

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Introduction

Feedback is an important part of the learning process for students, and helps facilitate learning. Feedback may be given as formative or summative assessment of students' learning and knowledge. Summative assessment is retrospective feedback, in which students' learning is evaluated at the end of the learning experience, like an exam. Formative assessment is prospective feedback, in which the students' learning is continuously monitored, and they receive ongoing feedback to facilitate learning. For feedback to be useful for the students, it is important that the student see the relations between the learning objectives and the feedback, and that the feedback do not come too late in the learning process (Rienecker & Bruun 2013). Formative assessment is much more likely to enhance self-efficacy in students than summative assessment (Hattie 2012), where the feedback might come to late in their learning process to make a difference. Studies show that students want clear, explicit and constructive feedback that are learning-oriented, continuous and timed so it may be used prospectively (for review, see Rienecker & Bruun (2013))

According to John Hattie (2012), effective assessment for learning is based on the five key factors that:

1. *"students are actively involved in their own learning processes",*

2. *"effective feedback is provided to students",*

3. *"teaching activities are adapted in response to assessment results"*

4. *"students are able to perform self-assessments"*, and

5. *"the influence of assessment on students' motivation and self-esteem is recognized"*.

From this, it is clear that the students need to take an active role in their own learning process and that proper feedback will help students to be able to assess their own learning. For feedback in classrooms to work best, it is also important to clarify and share the intended learning objectives as well as have learning activities and discussions that provide indications of the students' understanding of the curriculum in order to give feedback that facilitates learning. Student activities within the learning objectives not only provides the teacher with feedback on the students learning and his/hers own effectiveness of their teaching, but also provides the students with the ability to conduct self-assessment of their learning.

Formative assessment can be obtained by activities performed by the teacher or students that give feedback about the students learning, which then can be used to modify the teaching and learning activities. However, assessments can be time-consuming and need to be made manageable and time-efficient (Brown & Race 2013). One way of saving time is to give feedback collectively instead of individually. Moreover, activities could be performed fast, by using rapid prompts during the lecture or brief student activities covering the learning objectives. Thus, including feedback of students learning in a lecture may not take extra time to prepare, but may provide an opportunity to adapt the teaching to optimise the learning possibilities for the students and facilitate learning.

Problem definition

The course 'Fundamentals of Neurobiology' was the final course of a series of 'Fundamentals' courses at the Danish Research Centre for Magnetic Resonance. Most of these courses were held for the first time within the last year. However, the learning objectives for some of these courses were not clear, and the students appeared disengaged during the courses with unclear learning objectives. Moreover, some students did not learn what was intended, or they say that they only learned something by reading the curriculum, and not by the teaching. Because of the lack of clear learning objectives in some courses, it has been difficult for the teachers and students to assess the students' learning. In some courses, there were no evaluations of the students learning, and it is unknown what parts of the curriculum the students learned and to what extent they learned it. In the present project, I wished to make clear learning objectives for all the lectures and to use student activities to conduct continuous formative assessment throughout the Neurobiology course. I hoped this would engage the students, facilitate learning, and enable the students to guide their self-assessment of their learning, as well as enable me to modify my teaching according to the students learning of the intended learning objectives.

Objectives

The aim of the study was to gain experience with continuous formative assessment of the students' learning by means of student activities to engage the students and facilitate learning in a lecture setting. Specifically, the study aimed at assessing the students' knowledge of the lecture's learning objectives before and after the lecture. This would provide me, the teacher, with some feedback about the students learning during the lecture for me to adapt the teaching to guide the learning experience of the students, as well as to provide the students with clear learning goals to guide their continuous self-assessment of their learning.

Methods

Course overview

The course "Fundamentals of Neurobiology" is part of a series of 'Fundamental' courses at the Danish Research Centre for Magnetic Resonance (DRMCR) at Copenhagen University Hospital Hvidovre. The DRCMR has many Danish and international undergraduate and graduate students with different educational backgrounds. To ease the students' introduction to a highly interdisciplinary research field, it had been a wish from both the students and the senior researchers in the department to create a series of "Fundamentals" courses for all undergraduate and graduate students in the department. The series of Fundamentals courses (in Maths, Statistics, MRI, Study design, Neuroimaging, and Neurobiology) began in August 2014 as an annual curriculum, and the Neurobiology course was held in May-June 2015 for the first time. The neurobiology course consisted of six 1-hour lectures with approximately one lecture per week. Attendance was voluntary. I was the course responsible, selected the curriculum, and planned and conducted all the teaching myself. The level of the course was equivalent to a third or fourth year elective course at the university with little prior neurobiology needed to attend the course.

Student background

A total of 24 students (6 MSc students, 12 PhD students, 6 Postdocs) participated in the Fundamentals of neurobiology course. The students had many different educational backgrounds spanning from psychology and medicine to engineering and physics (see Table 21.1). Moreover, some of the students had never had any previous introduction to neurobiology, some had read about the topic themselves, and others had followed one or several neurobiology courses. The neurobiological background of the students is presented in Table 21.2. The course curriculum and lectures were mainly aimed at accommodating the students with no, little or some neurobiological background, but students, who previously had followed several neurobiology courses, could come to the lectures to brush up their knowledge. The participation rate in all six lectures was highest for the students with no or little previous neurobiology exposure, and lowest for the students, who had already followed several neurobiology courses (see Table 21.2). The course participation rate, thus, appeared to reflect the target audience of lectures and course.

Table 21.1. Educational background of the students following the course.

Educational background	N
Psychology	7
Engineering	5
MD	4
Neuroscience	3
Linguistics	2
Physics	2
Radiographer	1

Table 21.2. Neurobiology background and participation rate of the students.

Neurobiological background	N	Participation rate
None	2	100 %
Own reading	5	70,8 %
Followed one neurobiology course	9	64,8 %
Followed several neurobiology courses	7	57,1 %

General study design

The aim of the study was to gain experience with continuous formative assessment in a lecture setting to help facilitate student learning. In order to do this, learning objectives for each lecture were made, and students' knowledge of the learning objectives was assessed in the beginning and in the end of each lecture. The study used the following design:

1. Make learning objectives for each of the lectures
2. Design and prepare student activities for each lecture that covered the learning objectives
3. Present the lecture's intended learning objectives in the beginning of the lecture
4. Assess students knowledge of the lecture's learning objectives
5. Lecture, including additional student activities and discussions
6. Assess students knowledge of the learning objectives at the end of the lecture
7. Summarizing, explaining, discussing and/or reflecting on the learning objectives in plenum, peer-to-peer or by teacher at the end of the lecture

The student activities were centred on the lecture's learning objective. Data was collected before the lecture to assess the students' prior knowledge of the learning objectives, and by the end of the lecture to assess if the students knowledge of the learning objectives after the lecture. This design allowed for comparison of the students' knowledge of the learning objectives before and after the lecture, which was used as an indicator of student learning during the lecture. In case the students did not appear to have learned the intended learning objectives, the teacher could allocate additional time to explain or discuss parts of the learning objectives. Data was collected from student activities in five out of the six lectures. In the present project, I only used data collected from three of the six lectures (Table 3), using questionnaires, mind-maps, or an essential overview figure.

Table 21.3. Assessment method of students' knowledge of learning objectives.

Lecture	Number of students	Data collected	Method
1	21	20 before/18 after	Questionnaire
2	14	14	Mind-map
4	22	16	Overview figure

Questionnaires

For the first lecture, students filled in a questionnaire online 1-2 days before and 6-13 days after the lecture using the free web-based survey solution SurveyMonkey (https://da.surveymonkey.com). The questionnaire given after the lecture is presented in Table 21.4. The questionnaire given before the lecture consisted of Questions 3-7. The questions covered the lessons learning objectives (Table 21.5).

Table 21.4. Questionnaire used after lecture 1. Questions 3-7 also used before the lecture.

1. Did you read the chapter before the lecture?
2. Have you read the chapter after the lecture?
3. Name the three glial cell types in the brain:
4. What three main morphological regions does a neuron have?
New page:
5. What is the structure neurons communicate with called and what does it consist of?
6. What is/are the primary function(s) of: Oligodendrocytes: Astrocytes: Microglia:
7. What function does the blood-brain barrier serve?

Mind-map

In the second lecture, the students were asked to make a mind-map of their knowledge on "membrane potential" and "axon potential" with the lecture's intended learning objectives in mind (Learning objectives; you should be able to explain what a membrane potential is at rest and how it can change dynamically; explain what an axon potential is and how it works). Students made the mind-map using a green pen in the beginning of the lecture and added to the mind-map with a red pen in the end of the lecture (see Figure 21.2). When finished, the students discussed the mind-maps with their peers, and in the end, knowledge gaps in the mind-maps were discussed in plenum.

Essential overview figure

In the fourth lecture, an essential overview figure (Figure 21.1), capturing the essence of the lecture's learning objectives, was used to assess the students' knowledge of the learning objectives. Students filled in the empty boxes in the figure with a green pen in the beginning of the lecture and with a red pen at the end of lecture. The figure was then gone through and discussed in plenum in the end of the lecture, and boxes that the students had difficulties with were explained and discussed.

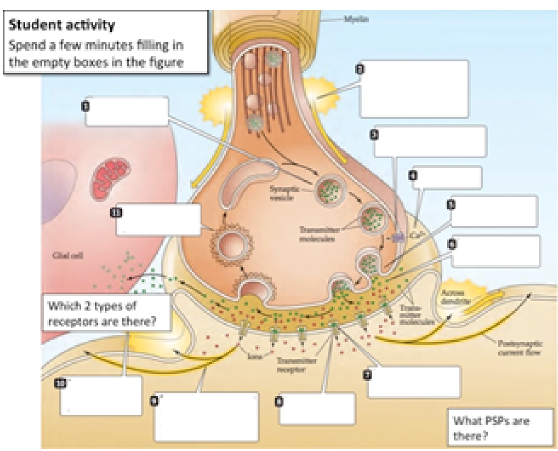

Fig. 21.1. Essential overview figure capturing the lecture's learning objectives. Students filled in the empty boxes in the beginning and the end of the lecture.

Evaluation

At the end of the last lecture, students gave oral feedback in plenum about what they liked and did not like about the course. Moreover, they students were specifically asked about their view on having to do the same student activity in the beginning and end of the lecture. Finally, the students were asked to reflect on their learning experience with this setup for a few minutes and send their reflections by email.

Results and experiences

Lecture 1: Questionnaires

Five questions in the questionnaire covered the lecture´s four learning objectives, which are presented in Table 5 together with the percentage of students that got correct answers for each of the four learning objectives before and after the lecture. Most of the students already had obtained the first (93%) and fourth (90%) learning objective before the lecture. Thus, the lecture was adapted beforehand to allocate more time to the second and third learning objective, which, respectively, only 50% and 38% of the students got corrected before the lecture After the lecture, an additional 44-51% of the students were able to correctly answer the questions covering the second and third learning objectives. Thus, it appears as if the additional time spend on these learning objectives during the lecture might have been wisely spend. As the questionnaire was filled in after the lecture, feedback was given in the beginning of the second lecture two weeks later, which appeared somewhat suboptimal given the relatively long time interval between the two lectures.

Table 21.5. Correct response to questions within each learning objectives before and after the lecture.

Intended learning objective (Students should be able to:)	Before	After
1) State the general features of neurons	93%	100%
2) Name the three major glial cells types in the brain	50%	94%
3) State some of the primary functions of the different glial cells	38%	89%
4) Explain the function of the blood-brain barrier	90%	90%

Lecture 2: Mind-map

In the second lecture, the students made a mind-map of their knowledge on “membrane potential” and “axon potential” with the lecture’s intended learning objectives in mind in the beginning and in the end of the lecture. Examples of mind-maps are given in Figure 21.2.

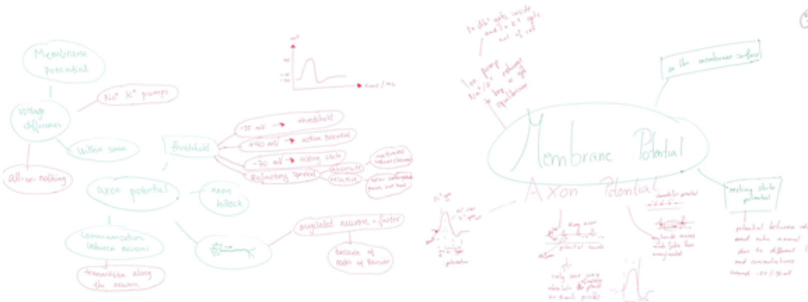

Fig. 21.2. Example of two mind-maps. Students used a green pen to make the mind-map in the beginning of the lecture, and added to the mind-map with a red pen in the end of the lecture.

In general, there were large variability between the students in the amount of information and details given in the mind-map. Some students were able to make detailed mind-maps already in the beginning of the lecture, while other students were unable to write anything. Though it is difficult to quantify mind-maps, all mind-maps were evaluated on whether the information on the mind-map were correct and detailed enough to indicate that the student had obtained the learning objectives, both in the beginning and end of the lecture. For the ‘axon potential’ learning objective, five out of 14 students appeared to fulfill the learning objective in the beginning of the lecture, while this had increased to 13 out of 14 students by the end of the lecture. For the ‘membrane potential’ learning objective, 11 out of 14 students appeared to fulfill the learning objective in the beginning as well as end of the lecture. However, two students had not included membrane potential on the mind-map, and, thus, it is unknown whether they forgot to write it down or whether they did not know anything about the topic. Qualitative evaluation of the mind-maps revealed that all students had added more information to the mind-map in the end of the lecture, including general information on the topic, drawings, as well as details. Thus, even students that already had sufficient knowledge about the learning objectives appeared to either have learned something or refreshed their knowledge on the topic. Finally, the knowledge gabs in the mind-maps were discussed peer-to-peer, and in plenum.

Lecture 4: Essential overview figure

In the fourth lecture, students had to fill in 11 empty boxes in an essential overview figure using a green pen in the beginning and a red pen in the end of the lecture. In general, students had filled in more boxes in the end than in the beginning of the lecture. In the beginning of the lecture an average of 6.1 out of 11 (range: 2-11) boxes had been filled in. In the end of the lecture, an average of 6.5 (range: 1-10) boxes had information added, so that an average of 10.2 of the 11 (range 7-11) boxes had been filled in. Next to having more boxes filled in, the boxes also contained more information, more details, and corrections had been made. Examples of additions and corrections made from the beginning to the end of the lecture are presented in Table 21.6. Finally, the overview figure was then gone through in plenum with students responding on what should be in each box. The boxes that some students had difficulties with were explained and discussed by the peers and teacher in plenum, and misconceptions were clarified. It appeared as if the students had understood the learning objectives by the end of the lecture, as well as in the two following lectures, where the learning objectives from this lecture were essential background knowledge.

Table 21.6. Examples of edits made in overview figure from the beginning to the end of the lecture.

Type of changes	Before	After
Additions:	Ion channel	Voltage-gated Ca^{2+} channel open, Ca^{2+} influx
	Open ligand-gated ion channel	Ion-channel=receptor, transmitter bind to receptors
Corrections:	Synaptic cleft	Ca^{2+} influx
	Ion channel opened, Ca^{2+} release	Voltage-gated ion-channel open, Ca^{2+} influx

Evaluation

The students evaluated the course orally after the final lecture. In general, all students liked that clear learning objectives had been presented in the beginning of the lecture. Furthermore, all students liked that there had been student activities, particularly the activities during or at the end of the lecture. However, only some students found the student activity in the beginning of the lecture helpful, while others thought it was a waste of time. There was also some variability in which of the student activities the students liked, in that some liked the quiz, others the figure and yet others the mind-map. However, the students agreed that variability in the student activities had been nice. In addition, all students liked that the learning objectives and answers were discussed in the end with the peers and/or the teacher. Finally, I asked to get some written feedback from the students on how they felt about the learning objectives, the student activities and the setup of the lectures. Here are some of the statements from the students:

Student 1: *"I thought it was a huge help to get the clear learning objectives as well as the mind-map exercises. It was a great help when reading and it also made me more curious when reading. I also think that the information stick better to the memory. I liked the quiz before and after, but I also thought that it was nice it was not the same each time, because I think that might have been too much. Then it was nice that you changed between different formats (quiz, red/green pen etc.)"*

Student 2: *"Starting with getting the objectives and trying to remember what you already knew about the subject was a good starting mode: you got reminded of things that you perhaps once knew and felt you should know better, which helped focus the attention during the subsequent lecture. It was also a motivation in the sense that you knew you were going to fill out your paper again later and then wanted to improve. Filling it out in the end also served as a nice recap and you left with the feeling that you learned something in class."*

Student 3: *"To get the learning objectives in advance, in the beginning, but also before the lecture is very good. I found it the most useful to fill out the learning activities after the lecture, and especially to discuss the answers with the lecturer and the peers. But of course, it was a bit funny to see how much more you could remember after compared with before the* *lecture. I liked the figures with the empty boxes best. Also the black board lists, where the students should tell everything they've learned at the end - a good recap of the lecture"*

Discussion

Students' knowledge of the lecture´s intended learning objectives was assessed before and after the lecture using different types of student activities. Comparing the student's knowledge of the learning objectives before and after the lecture revealed considerable learning of the learning objectives during the lecture. Moreover, for some of the student activities it was clear that even for students that already had obtained the learning objectives before the lecture, additional learning or refreshment of knowledge occurred.

Originally, I became interested in conducting this project to receive feedback on my own effectiveness as a teacher as well as how I could help the students facilitate learning via student activities and feedback. When reflecting on this matter, I did receive a lot of input on my own teaching skills, on which student activities seemed to work and which needed further development and on how to get information about the students learning. Moreover, it was interesting to see how little effort it actually required to change and adapt the teaching according to the information I received from the students' learning during the student activities. By receiving continuous information about the students' ongoing learning, it required little additional effort or time to further explain and discuss some of the topics that the students found more difficult as well as catch potential misconceptions, and correct these immediately. One student wrote that "*I found it the most useful to fill out the learning activities after the lecture, and especially to discuss the answers with the lecturer and the peers. … Also the black board lists, where the students should tell everything they've learned at the end - a good recap of the lecture*". Moreover, as all students liked that the learning objectives and answers were discussed in the end with the peers and teacher, this might reflect that the students felt they learned something from receiving collectively feedback on correctness of their learning.

While I think I received a lot of input on my own teaching skills, and input on how to get information to adapt my teaching and provide better feedback to the students, it quickly became clear to me that a really important aspect of formative assessment was getting the students actively involved in their own learning process. The student activity before the lecture appeared to promote the students' self-assessment of their current knowledge of the lecture's learning objective and made it clear to the students that they might have some gaps in their knowledge. Similar to this thought, one student noted that: *"you got reminded of things that you perhaps once knew and felt you should know better"*. Moreover, it appeared as if the students' ability to conduct self-assessment during the student activities also motivated the students to further learning, e.g. *"It was also a motivation in the sense that you knew you were going to fill out your paper again later and then wanted to improve"* and increased their self-esteem, e.g. "*Filling it out in the end also served as a nice recap and you left with the feeling that you learned something in class*". In the end of the lecture, students received feedback on their concepts and knowledge of the learning objectives, and were able to discuss the learning objectives and potential misconceptions with their peers and the teacher. This allowed for further self-assessment of their learning. Finally, a student noted that: "*there were clear learning objectives and quizzes. It was a great help when reading and it also made me more curious when reading. I also think that the information stick better to the memory*", suggesting that getting the learning objectives and student activities before reading the curriculum, have helped guide some of the students and their learning process when reading the curriculum.

In the present project, data was collected using three different kinds of student activities; questionnaires, mind-maps and an overview figure. Different students like different activities, but the students agreed that it had been nice that different activities had been used. It should be kept in mind that different activities provide different kinds of information regarding the students' learning. An overview figure is a very concrete task and may provide information about the students learning of a limited topic, questionnaires may be made simple or complex depending on the learning objective, and may be used to get information about concrete questions as well as about the students' conceptualization of a certain topic. Further, a mind-map may both capture the students' knowledge of details as well as their conceptualization of the topic. All student activities used in the present project have their pros and cons, so note, it is important to keep in mind what the learning objectives are, and to choose student activities accordingly.

The same student activity was performed twice, once in the beginning and once in the end of the lecture. This was done to compare the students' knowledge of the learning objectives before and after the lecture to infer something about the students' learning during the lecture, and was merely a study design to collect data. While it appeared to help some students focus their attention and made them aware that they learned something during the lecture, it may not be realistic time-wise to do this in future lectures. Moreover, it might not have been the student activity in the beginning of the lecture per se that helped focus the students' attention, it may have been the additional time allocated to clarifying the learning objectives. In the future, it might be worth testing whether additional time allocated to go through the learning objectives either before or in the beginning of the lecture yield the same result. Finally, a student noted that: "*I think it is much better to have the same learning objectives repeated (shortly) as the first thing in the next lecture - and maybe do this in the way where the lecturer asks the students to tell what they have learned / how much they remember*". It is definitely also worth trying to repeat the previous lecture learning objectives in the beginning of the next lecture, as repetitions facilitates memory.

In this project I only scratched the surface of how formative assessment may be used to facilitate learning in students. I tried three different student activities to get information about the students' learning in order to adapt the teaching activities to facilitate student learning as well as give the students feedback on their learning. It was definitely worth the time and effort to get information about the students learning and to evaluate the students learning formatively. Misconceptions were easily caught, and clarified through discussions with peers and the teacher. It required little additional effort from me, but it was a great satisfaction to be able to assess that the students had in fact learned what was intended. Finally, the clear learning objectives and student activities also appeared to help students read and memorize the curriculum and guide their self-assessment of their learning. I recommend other teachers to dive into using continuous formative assessment in their teaching, and I will continue to strive to develop my teaching around continuous formative assessment of the learning objectives.

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Anvendelse af Teaching and Learning Activities (TLA) i anatomiundervisning på medicinstudiet

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Baggrund

Jeg underviser 5. semester medicinstuderende i makroskopisk og mikroskopisk anatomi (indre organer). Der er ca. 11 hold af 24 studenter, hvoraf jeg underviser et hold og resten af holdene er fordelt mellem 7 studenterundervisere. På 5. semester har de medicinstuderende to organkurser (hvor der undervises i anatomi, fysiologi og biokemi). Det ene "organkursus i nyre og urinveje" har 4 SAU lektioner i anatomi, mens det andet "organkursus i blod, endokrinologi og reproduktion" har 17 SAU lektioner i anatomi. SAU står for "Studenter Aktiverende Undervisning", som afløste "Eksaminatorier" for et par år tilbage. I praksis betyder det holdundervisning. Begge organkurser afsluttes med en fælles eksamen der er delt op i spørgsmål i anatomi, fysiologi og biokemi. Fagene rettes også af fagspecifikke eksaminator. Jeg laver eksamensspørgsmålene i anatomi og retter ca. 1/3 af alle opgaverne. Jeg er delkursusleder, dvs. jeg er ansvarlig for anatomidelen af begge kurser.

Problem

Undervisningen foregår hovedsageligt på "den gammeldags" facon. Det er tradition på medicinstudiet at de fleste SAU timer afholdes på "forelæsningsform" dog iblandet spørgsmål ud til studenterne der kan være meget faktuelle. Mange af underviserne, mig selv inklusiv, er selv blevet undervist på den måde. Vi (eksamenskollegiet) syntes generelt ikke at de studerende er ”gode nok” til anatomi efter eksamen på trods af, at de består. Og er det så et problem? Det mener vi så absolut det er fordi det er grundlæggende viden de skal bruge til at tillære sig ny viden i fagene på kandidatdelen hvor det jo handler om medicin og kirurgi. Det er jo svært at lære om kirurgiske indgreb hvis man ikke kender den grundlæggende anatomi og det er også svært at forstå sygdomsmekanismer i organer man ikke ved hvordan er opbygget. Det er både et problem for de studerende, da deres videre læring på studiet bliver dårligere, det er et problem for undervisere senere hen på studiet og i sidste ende kan det desværre blive et problem for patienterne. Det er sværere at forstå og tolke symptomer hos patienter og tolke undersøgelsesresultater hvis man ikke kender anatomien. Så vi mener vi står med et stort og reelt problem.

Der er ganske givet mange faktorer der bidrager til problemet såsom eksamensformen og et uhyrligt stort pensum på meget kort tid. Disse faktorer er dog i denne henseende et vilkår, som ikke behandles yderligere. Men vi kan og bør forsøge at ændre på undervisningsformen, for at undersøge om dette kunne forbedre de studerendes basale anatomividen efter kurset.

Vi (studenterunderviserne og jeg) er interesseret i at gøre SAU timerne bedre på en måde der skal øge de studerendes læring under kurset. Vi vil meget gerne motivere dem til at læse på stoffet inden timerne og til at deltage mere aktivt. Mit projekt skal derfor tage udgangspunkt i at SAU undervisningen ændres med fokus på forberedelse og aktiv læring. Mit mål er at anvende Teaching and Learning Activities (TLA) i udbredt grad, og forelæsningsformen minimeres. Desuden så vil jeg lave specifikke og detaljerede læringsmål for hver eneste aktivitet, også for de emner der ikke nås i timerne, der skal hjælpe de studerende med at sortere i det enorme pensum. Mit håb er at jeg kan lave opgaver hvor de skal anvende deres viden og at de derved lærer stoffet grundigere, men også at de motiveres til at forberede sig da de vil få meget mere ud af aktiviteterne hvis de er forberedt inden timen. Desuden at læringsmålene skal gøre forberedelsen mere struktureret og hjælpe med at overskue pensum, hvorved de også motiveres mere til at læse.

Bagrund for valg af metode

Jeg lavede for-projekt om Teaching and Learning Activities (TLA), forprojektet undersøgte om brugen af flere TLA kunne øge de studerendes motivation. Motivationen kan påvirkes af læringssituationen, så underviseren har mulighed for at påvirke de studerendes motivation (selvfølgelig i begge retninger) (Skaalvik & Skaalvik 2007). Jeg vil gerne forsøge at påvirke de studerendes motivation i en positiv retning. Der er forskellige teorier om motivation, men samlet set bygger de på, at motivationen øges hvis man føler sig i stand til at klare en opgave (Bandura 1997), føler sig kompetent og har selvbestemmelse (Ryan & Deci 2000) og hvis opgaven viser sig at have en form for værdi i forhold til omkostninger (Wigfield & Eccles 2002).

Hvis opgaven i dette tilfælde lyder på at blive rigtig god til anatomi, så skal vi lave nogle tiltag der øger de studerendes motivation for netop dette. Hvis de føler at eksamen er for svær og uoverskuelig, de har svært ved at gennemskue hvad de skal lære fordi læringsmålene er for diffuse, de føler der er en chance for at de ikke klarer opgaven, så ses det af ovenstående at motivationen falder. På vores kursus findes der meget få sætninger der beskriver læringsmålene og det siges ofte at "pensum er bogen". Bøgerne har et meget højt detaljeniveau, som vi aldrig kunne finde på at spørge ind til ved eksamen, så det siger sig selv at motivationen falder når det hele er diffust og uoverskueligt. Derfor har jeg besluttet at den ene intervention er at definere en række mere specifikke *læringsmål* for hver enkelt lektion, som de også kan læse til eksamen ud fra.

Det er også vigtigt at øge motivationen med at præcisere overfor de studerende hvad værdien i den givne opgave er. Da værdien i opgaven ofte på kort sigt ligger i, at den viden de opnår umiddelbart efter skal anvendes for at forstå fysiologien, så opfyldes dette nemt ved at minde dem om det, men dette kræver at der holdes en stram alignment mht. hvornår undervisningen planlægges. Dette har vi dog på forhånd ret godt styr på. Det kræver også at underviseren kan lave alignment til de andre fag, altså kender til læringsmålene i fysiologi og bedst er det hvis de selv har gennemgået samme uddannelse. Dette er hovedårsagen til at vi kun bruger medicinstuderende (eller læger) til at undervise. Det ideelle ville være at samme underviser varetog undervisningen i fysiologi samtidig med, så ville værdien blive meget tydeliggjort. Dette er dog ikke en reel mulighed. Min intervention på dette punkt er, at de studerende i nogle opgaver bliver bedt om at definere vigtigheden af den viden de lige har opnået.

Derfor vil jeg gerne skabe en læringssituation der understøtter motivationen og som samtidig gør at deres læring øges. Jeg har via vores forprojekt og deltagelse i pædagogikum lært, at hvis læringssituationen faciliterer aktiv læring vil dette øge de studerendes udbytte af undervisningen.

Dette kan opnås ved at indføre forskellige former for TLA hvor udgangspunktet er at de selv skal komme frem med ”løsningerne”, altså hvor de selv skal sætte ord på og selv forestille sig den anatomiske viden ved at anvende eksisterende viden. Rent praktisk vil det foregå på den måde at undervisningsformen ændres radikalt fra den traditionelle måde til en undervisningsform der gerne skulle bestå af så lidt undervisergennemgang som muligt. De skal i timerne udføre forskellige opgaver, der har det formål at de ender med at have gennemgået stoffet. Nogle opgaver vil være rent “hvad kan du huske fra forelæsningen og det du har læst hjemme opgaver” hvor navngivningen af strukturer har fokus. Nogle vil være at gennemgå noget for hinanden og have fokus på hvad denne viden kan bruges til og nogle vil igen være øvelser hvor de anvender virtuel mikroskopi. Desuden vil jeg have meget fokus på at de selv kommer frem til et svar, altså svare på et spørgsmål med et spørgsmål. Opgaverne hvor organet skal beskrives (som ligner meget eksamensopgaverne) skal udformes således at det til at begynde med er meget defineret hvordan de skal gå til det, men efterhånden skal de selv have forstået konceptet.

Fordele jeg gerne vil opnå med denne form for undervisning er: Forhåbentlig vil de være mere fokuserede i undervisningen da de skal deltage aktivt, der er ikke rigtig plads til tankeflugt. Alle opgaver skal løses i små grupper, derfor kan det bevirke en større lyst til at svare og deltage aktivt i fællesundervisningen, da man på den måde ikke er alene om at svare forkert. Jeg vil kunne tillade mig at spørge specifikke personer, de vil ikke føle sig udstillet som enkeltpersoner. De finder ud af at de får et større udbytte af undervisningen når de er forberedt. De vil føle sig kompetente, da de i starten lærer konceptet som skal udnyttes til eksamen. Der vil opnås en bedre alignment mellem undervisningen og eksamen, da eksamen jo består af opgaveløsning. Der vil opstå en bedre alignment mellem de andre fag (fysiologi) idet dette inddrages en smule for at styrke motivationen. Der vil opstå en bedre alignment mellem forelæsningen og holdundervisningen, da denne vil understøtte forelæsningen og ikke gentage den.

Der er dog helt tydeligvis også nogle ulemper ved denne form for undervisning. Den altoverskyggende er tiden! Pensum er virkelig stort, så der vil være en meget stor del der slet ikke gennemgås i timerne. Det er en stor risiko at tage, da dette kunne øge sandsynligheden for at de ikke lærer den del så godt. Men det er meningen at de skal lære en måde at tilgå stoffet på og også bruge den på det til timerne udeladte. Desværre er de studerende på dette semester meget tidspressede, og det er sandsynligt at de ikke når dette. Der vil derfor være hele organer der kun bliver gennemgået til forelæsningen. Udvælgelsen vil foregå efter relevans, vigtighed og sværhedsgrad, sådan at det der er svæerst at forstå og læse på selv, bliver gennemgået, dog udelades ikke organer der er meget vigtige at have viden om. En anden ulempe er at traditionen brydes. Mange medicinstuderene føler sig godt tilpas i forelæsningssituationer og ønsker ikke at de skal aktiveres i undervisningen. Det er meget udbredt at anatomi øves intensivt med sin læsemakker, som jo på en måde gør det ud for aktiv læring, derfor vil nogle studerende savne at få pensum "serveret" i SAU timerne.

Metode

Til hver enkelt lektion udarbejdes meget detaljerede og specifikke læringsmål. Disse vil være at finde på Absalon forud for lektionen. I semesterets første lektion informeres studenterne om hvilken form for undervisning de vil komme til at opleve. De informeres også om grunden til dette, altså at det er bagrund for denne opgave. I starten af hver lektion præsenteres dagens læringsmål og det gøres klart hvad der bliver gennemgået og hvad der er selv-studie. Dette vil også være tilgængeligt på Absalon inden timen. Til hver lektion udarbejdes aktiviteter i form af 5-6 opgaver der udleveres ved undervisningens start . Jeg vil hjælpe undervejs i løsning af opgaven og efter hver opgave skal de studerende gennemgå løsningen for hinanden, enten i grupper eller i plenum. Det vil sige, det stof der bliver spurgt til ikke er gennemgået først. Disse opgaver bygges ind i et power point show, så der efter hver opgaveløsning er en gennemgang af stoffet samt løsninger hvor dette er hensigtsmæssigt. Power points kan derfor bruges efter behov for gennemgang efter hver opgave, forhåbentlig kan de fleste slides hoppes over. Men i power point showet findes også gennemgang og måske opgaver til det pensum der ikke nås. De studerende kan hente power points på Absalon og derved bruge dette til repetition. Til sidst i hver lektion vil læringsmålene blive repeteret og der opsummeres på hvad der blev gennemgået og hvad der er selv-studie.

For at besvare hypotesen om at den form for undervisning vil øge deres motivation og forberedelse vil de studerende efter kurset blive bedt om at udfylde et spørgeskema og hvis det er muligt vil jeg invitere nogle af dem til et fokusgruppe interview. Skemaet er opbygget så der spørges til: Deltagelse, holdning til studenter aktiverende undervisning og udbytte af at deltage aktivt, holdning til at noget stof udelades og endelig om de fik udbytte af de detaljerede læringsmål. Da de til eksamen ikke får en karakter for deres anatomi, men kun en samlet karakter, vil de også blive bedt om at give deres eksamens nr., da jeg derefter kan gå ind og se hvad anatomikarakteren var.

For at jeg kan følge med i udviklingen vil jeg efter hver lektion skrive et notat om hvad der gik godt og mindre godt, så undervisningen kan tilrettelægges til næste time. Mine overvejelser omkring undervisningsformen og studenternes reaktion i timerne vil også indgå i evalueringen.

Evaluering

Forløbet fra mit synspunkt:

De første timer startede rigtigt godt. Det var desværre et meget lille hold med kun 10 holdsatte studenter, hvilket jeg af erfaring ved er meget sårbart, da en del falder fra i løbet af kurset. De var dog meget positive, ville gerne i gang med TLA og var meget velforberedte, så min plan om at de stort set gennemgik det hele selv, lykkedes til fulde i starten. Især var det meget vellykket i mikroskopi timerne, da de kunne sidde og lave mikroskopi øvelser på vores virtuelle mikroskopi system på computer (som at kigge flere i samme mikroskop) og jeg gik rundt og hjalp. De fik en langt større fornemmelse for hvad de kiggede på, fordi de var nød til at reflektere over hvad de så. I de makroskopiske anatomitimer fik de også mere ud af det, men her var problemet med tiden stort, der var for meget der ikke blev nået i selve undervisningen, hvilket bekymrede mig.

Men som kurset skred frem blev de meget presset på tid og selvom de ønskede at forberede sig, var der ofte timer hvor ingen havde læst stoffet, og det var nødvendigt med en gennemgang før opgaverne. Der var også et frafald af studerende, til gengæld dukkede nye fra andre hold op der havde hørt om den anderledes undervisningsform, så det var jo positivt. Dog var der ofte undervisning med 3-5 studenter. Da var kun et par stykker fra det originale hold der ”holdt ved” hvilket betød at det var svært at holde en kontinuitet, da der næsten var nye hver gang. De ønskede hen ad vejen at undervisningen skulle foregå mere og mere på “gammeldags facon” de havde simpelthen brug for at få det gennemgået af mig, ofte fordi de ikke følte sig velforberedte nok til at lave TLA. Alle var enige om at selve opgaverne og øvelserne var gode, men kun hvis de havde nået at forberede sig. De var positive overfor de detaljerede læringsmål, dog udtrykte de stor bekymring om, at der var stof der slet ikke blev gennemgået.

Studenterne:

Desværre endte det med at der kun var ganske få i den sidste time og jeg måtte finde på en måde at få dem til at udfylde mit spørgeskema på. Jeg ønskede også at få evaluering fra ”afhopperne”, samt dem fra andre hold som jeg ikke havde mailadresser på. Jeg skrev derefter på Absalon og annoncerede efter studenter der havde været på holdet, fik deres mail-adresser og sendte spørgeskema ud til dem samt til de holdsatte, i alt 20 studenter. Jeg fik en student til at modtage, så de kunne være anonyme, og skrev at der ville udloddes et gavekort til bogladen på 300 kr. hvis alle 20 sendte skema retur. Ved deadline havde hun modtaget et enkelt skema retur! Dvs. jeg havde to evalueringer! Jeg forsøgte i to omgange mere at skrive ud og bede dem om at udfylde skemaet, det resulterede i alt 6 skemaer tilbage, to af dem med uddybende kommentarer. Herefter opgav jeg at invitere til fokusgruppe interview. Der var kun to der havde opgivet eksamens nr., så der er ikke evalueret på karakteren.

Jeg har sammenskrevet svarene fra de fem skemaer

Deltagelse: 4 studerende var holdsat, en havde deltaget alle gange, to af dem næsten alle gange og den sidste 4 gange. Begrundelsen for høj deltagelse var for en enkelt at udbyttet var større ved den aktiverende undervisning, men en enkelt fordi tiderne passede godt og en anden fordi studenten plejede at følge undervisning. Begrundelsen for lav deltagelse var for den student netop at undervisningen var for studenteraktiverende og at studenten prioriterede at udnytte tiden til at læse hjemme. 2 studerende var ikke holdsat men deltog 2 og 4 gange, fordi de var utilfredse med den underviser de havde på eget hold.

Holdning til studenter aktiverende undervisning og udbytte: 4 ud 6 havde den holdning før kurset at studenteraktiverende undervisning var positivt for læring, men 2 foretrak enten lidt eller slet ingen aktivering i undervisningen. Ingen af studenterne ændrede holdning efter kurset. Dog svarer alle 6 ja til at det er lettere at svare på spørgsmål efter at have arbejdet med stoffet i grupper og at undervisningen bliver sjovere. Den ene student der ikke bryder sig om den form for undervisningen og derfor blev hjemme uddyber: *“... frustrerende at så meget tid gik med at skrive navne på tegninger og mikroskopere selv. Dette kursus var SÅ presset, så det havde givet et større udbytte at få gennemgået mere af stoffet. Det var en meget stor del af det* *som var selv-studie synes jeg. Ja jeg lærer mere når jeg selv arbejder med tingene, men det kan jeg gøre hjemme. I undervisningen har jeg brug for en, der er dygtigere end jeg selv, til at besvare alle de tvivlsspøgsmål der dukker op når pensum læses."*

Samlet set så er de egentlig enige om at selve det at få nogle aktiviteter ind i undervisningen øger udbyttet, men de er bekymret over tiden der bruges på det.

Holdning til at noget af stoffet bliver selv-studie: Her var 3 ud af 6 meget enige om at dette var frustrerende! Alle svarede at de var bekymrede, men de sidste 3 mente dog at det var ok, men kun så længe at det blev klart defineret hvad der skulle gennemgås med selv-studie.

Læringsmål: Her var alle enige om at de detaljerede læringsmål var et rigtigt godt redskab. De syntes alle det var en god ide. Næsten alle brugte dem til eksamenslæsning og til at forberede sig til undervisningen. 4 af studenterne mener også, at det at have de detaljerede læringsmål gjorde dem mere trygge i forhold til eksamen og at øger motivationen til at læse. Uddybet blev der skrevet: *"Det var et fantastisk tiltag med de læringsmål. Det var en stor hjælp"* og *"Læringsmål er rigtig godt, især fordi det gør at man få overblikket over stoffet og vide hvad der skal læses ekstra godt på"*.

Konklusion

Man må desværre konkludere ud fra mine egne oplevelser gennem undervisningsforløbet og de studerendes svar, at det at anvende studenteraktiverende undervisning på et så tidspresset kursus, skal gøres med forsigtighed! Men egentlig ikke fordi de studerende ikke ønsker det, eller kan se formålet med det, for det kan de sagtens. De var meget mere positive overfor det end jeg havde regnet med. Meget tyder på at tiden der anvendes i undervisningen er en afgørende faktor, jeg stadig føler mig overbevist om, at hvis alt pensum kan nås i undervisningen, så får de studerende et større udbytte af undervisningen når der anvendes TLA. Det er også vigtigt for gennemførelsen af undervisningen at de studerende har haft tid til forberedelse. På dette kursus er der også rigtig mange sider fysiologi og biokemi der skal læses sideløbende med, og de studerende har mange undervisningstimer hver dag, så det er naturligt at fravælge undervisning som forudsætter at man har forberedt sig, hvis man netop ikke har nået det. Jeg kan ikke ud fra forløbet og det indsamlede materiale konkludere at den intensive brug af TLA øger de studerendes motivation, tværtimod er der fra en student uddybet hvordan det nærmest er demotiverende. Jeg kan heller ikke konkludere at de studerende læser mere, da det jeg oplevede var at de forberedte sig lige lidt som de plejer. Tværtimod var der nogle der ikke mødte op, fordi den form for undervisning netop kræver forberedelse. Det er dog helt sikkert at de får meget ud af de detaljerede læringsmål. Jeg mener at kunne konkludere ud fra dette materiale at de specifikke læringsmål helt klart øger motivationen til forberedelse og eksamenslæsning. Derfor er dette et godt redskab at bruge i undervisningen og jeg vil sørge for at dette bliver implementeret på hele semesteret.

Med hensyn til min egen undervisning, vil jeg "skrue" ned for TLA, men klart forsøge at få nogle af de bedste øvelser puttet ind i de timer hvor der er tid til det. Det vil dog også afhænge af det enkelte holds ønsker og forberedelsesgrad. Jeg er stadig overbevist om at hvis tiden er til det, så er det den bedste måde at formidle selv anatomi på. Jeg tror derfor også på at selvom hele løsningen på vores problem måske ikke ligger i undervisningen (men også eksamensform og størrelsen af pensum), så kan mere tid til undervisningen være en del af løsningen. Det vil give underviserne mulighed for at lave mere studenter aktiverende undervisning.

23

Optimering af dybdelæring ved kombineret teoretisk og praktisk undervisning

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Introduktion

Kurset *Food Enzymes and Applications* (NFOK14021U) der bredt behandler enzymteknologi i fødevareproduktion er opbygget som et blokkursus (blok 3), hvor første halvdel består af forelæsninger inkl. gæsteforelæsninger af erhvervsfolk og sidste del udgøres af laboratoriebaseret projektarbejde i grupper. Forelæsningerne er med til at give de studerende en bred forståelse indenfor enzymer der bruges i fødevareproduktionen, hvorefter de studerende arbejder i dybden med en specifik gruppe af enzymer i laboratoriet. Kurset udbydes til MSc studerende og det er populært blandt udvekslingsstuderende. Typisk er der et sted mellem 20 og 30 studerende per blok.

I 2014 kørte vi et forløb af undervisning i emnet *carbohydrate degrading enzymes* bestående af 2 timers forelæsning, 2 timers case-arbejde samt 4 laboratoriedage med en projektgruppe. Gennem vores undervisning og vejledning af de studerende, har vi erfaret, at de studerende har svært ved at oparbejde en dybere forståelse af enzymernes funktionalitet samt at omsætte denne viden til praksis i laboratoriearbejdet.

Vi har i forbindelse med vores erfaringer fra 2014 samt vores lærdom fra Universitets Pædagogikum i år tilrettelagt forelæsning, case- og laboratoriearbejde med fokus på læringsmål, dialogbaseret, studenteraktiverende og problemorienteret undervisning. Yderligere har vi gentænkt laboratoriearbejdet i henhold til at føre en rød tråd fra case-emne til det praktiske arbejde samt gradvist at øge graden af *laboratory openness* over de 4 dage.

Gennemgående håber vi at kunne gennemskue, hvor de studerende mister tråden mellem den teoretiske viden og de observationer de gør i laboratoriet. Vi håber at kunne påvirke de studerende til at blive mere selvstændige og skrive en bedre projektopgave samt at opnå en dybdelæring på området.

Projektarbejdsforløbet

Forelæsning og case-arbejde

I undervisningsforløbet blev læringsmål (Biggs & Tang 2011*a*, Jørgensen n.d.) brugt til at aligne det faglige indhold i forelæsning, case- og laboratoriearbejde.

Under forberedelsen af forelæsningsgangen blev undervisningsmaterialet fra året før (2014) gennemgået for slides der understøttede læringsmålene specifikt og overflødige slides blev fjernet. Følgende læringsmål blev opsat:

- **Describe** the action of carbohydrate degrading enzymes on starch and β-glucans from cereals Substrate → Enzyme → Product
- **Differentiate** carbohydrate degrading enzymes according to their functionality
- **Decide** where and how to use carbohydrate degrading enzymes in a specific food process

Vi fokuserede på at åbne rummet for mere dialog og igangsættelse af flere aktiviteter (Haugsted & Ingerslev n.d., Krogh & Wiberg n.d.). Undervejs i forelæsningen blev der opsat spørgsmål til snak med sidemanden samt i plenum. Der blev indlagt flere stop, hvor de studerende italesatte, hvad de så på sliden med særlig fokus på læringsmålene og der blev fokuseret på at dvæle længere ved informationstunge slides så de studerende kunne sætte ord på enzymer og processer i spil.

Af to omgange blev de studerende i plenum bedt om at svare på quiz spørgsmål med det formål at gennemskue om de havde forstået teorien. Desuden forsøgte vi at understøtte forståelsen med "kognitive knager" (metaforer) over nogle af forelæsningens hjørnesten (substrat → enzym → produkt).

I umiddelbar forlængelse af forelæsningen igangsatte vi case-arbejdet som de studerende skulle udføre i grupper og derefter samle op på i plenum. Casen var et forskningsbaseret eksempel på enzymapplikation fra industrien – noget Mette Skau til dagligt arbejder med i sin postdoc. Denne problemorienterede tilgang gav de studerende nogle praktiske eksempler som motivation til at omsætte "svær teori" til praktisk arbejde (Dohn & Dolin 2013).

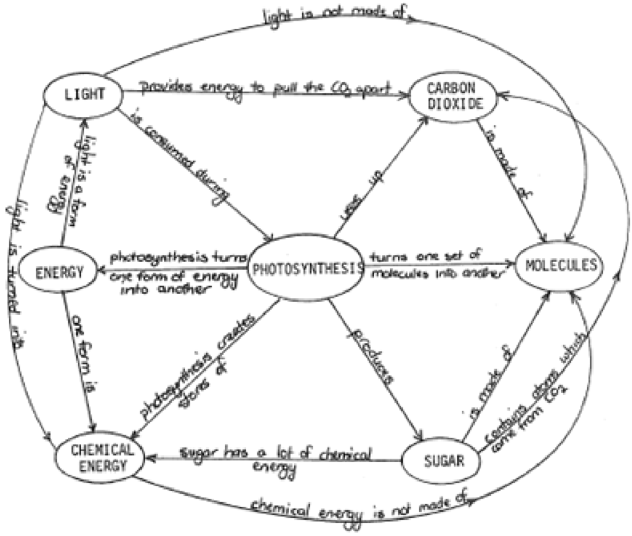
Laboratoriearbejde

I forlængelse af den teoretiske undervisning (forelæsning og case) lavede en gruppe af de studerende et projekt indenfor emnet *carbohydrate degrading enzymes*. De havde 4 dage til arbejdet i laboratoriet og derudover et par dage med mulighed for vejledning i forbindelse med projektbeskrivelse, diskussion af resultater, statistik, skriveproces mm. Arbejdstitlen på de studerendes projekt var "Development of a barley drink with fibre functionality" – med direkte link til case-arbejdet. I kursusbeskrivelsen var der lagt op til at projektets indhold skulle defineres af de studerende selv men med assistance fra os vejledere.

For at forsøge at sikre de studerende en dybere forståelse af den teoretiske viden samt hjælpe dem til at omsætte den til praksis i laboratoriet, valgte vi at inddrage en teoretisk øvelse undervejs i projektdelen. De studerende blev på dag 2 sat til at udvikle et begrebskort (Novak 1990, White & Gunstone 1992) (jvf. Figur 23.1) over emnet *carbohydrate degrading enzymes* – vores rolle var primært at rammesætte øvelsen og derefter følge med på sidelinjen. Øvelsen gik i praksis ud på at de studerende skulle placere post its med relevante fagtermer på tavlen og herefter forbinde sedlerne med pile der viste sammenhænge. Øvelsen skulle understøtte de allerede opsatte læringsmål (substrat $\rightarrow$ enzym $\rightarrow$ produkt). Ved at danne et loop fra den teoretiske viden over til det praktiske arbejde, håbede vi på at hjælpe de studerende til at:

- synliggøre viden for dem selv
- strukturere svært stof
- se den røde tråd mellem teoretiske viden og observationer i laboratoriet
- planlægge det videre laboratoriearbejde
- disponere projektopgaven

Vores erfaringer fra tidligere års projektarbejde i laboratoriet har antydet at der er stor forskel på hvor selvstændigt og problemorienteret de studerende



Figur 23.1. Eksempel på begrebskort (White & Gunstone 1992).

arbejder. Desuden har vi bemærket at nogle studerende møder op til laboratoriearbejdet og forventer en dags praktisk arbejde planlagt af vejlederen. De samme studerende har tendens til at tro at laboratoriearbejdet ikke nødvendigvis kræver en på dagen teoretisk tankegang. Vi mener at dette er en faldgrube til at miste den røde tråd mellem teori og praksis – noget som de ofte kæmper med at genfinde og inkludere ved rapportskrivningen.

Vi havde tilrettelagt dette års laboratoriearbejde således at vi overlod initiativet mere og mere til de studerende i løbet af de fire laboratoriedage (Tamir 1989), jvf. Tabel 1. Vi håbede derigennem at kunne øge de studerendes dybdelæring med det åbne spørgsmål som motivationsfaktor.

Resultater & diskussion

Forelæsning og case-arbejde

Først og fremmest har det at arbejde med læringsmål givet en god rammesætning for både de studerende og os undervisere, idet man er afklaret med at dagens "pensum" er i hus, samtidig med at snakken er gået på løst og

Tabel 23.1. Levels of Laboratory Openness (Tamir 1989).

LEVEL	PROBLEM	WAYS & MEANS	ANSWERS
0	Given	Given	Given
1	Given	Given	Open
2	Given	Open	Open
3	Open	Open	Open

fast indenfor emnet. Alignment via læringsmål vil fremover være et fast udgangspunkt for vores undervisning.

Det gav god dynamik i undervisningen at inddrage de studerende mere i snakken omkring slides – via spørgsmål og quizzer. Fremover skal der være endnu mere plads til dette, hvilket der også viste sig at være god tid til da læringsmængden var vel afbalanceret.

Fokus på forskningsbaseret undervisning via eksempler på anvendelse i industrien og case-arbejde med en aktuel proces gav generelt god feedback i form af engagerede og nysgerrige studerende. Brugen af "kognitive knager" er ligeledes noget vi tager med videre fremover. Efter undervisningen gav flere studerende udtryk for at det netop var de mange eksempler, der gav dem blod på tanden efter at komme ud og arbejde efter studiet. At kunne videregive sådan en motivation, mener vi, er rigtig vigtigt.

Vi mener, at de studerende ved dette års undervisning i *carbohydrate degrading enzymes* opnåede en dybere læring af stoffet godt hjulpet på vej af flere "loops" omkring de svære områder og mere dialog. Fremover vil vi som udgangspunkt lokalisere teknisk svære emner i undervisningen og bl.a. arbejde hen over disse flere gange undervejs.

Generelt gav de studerende udtryk for at de havde fået et godt udbytte af forelæsning og case jf. kursusevalueringen (Bilag A): "*Kulhydrat forelæsningen var rigtig god*". "*Mettes lecture, and the way she structured it was absolutely great! Probably my favourite lecture*". Ydermere, gav de studerende udtryk for at de gerne ville have tilsvarende case-arbejde indenfor de øvrige enzyme-områder. "*More case studies regarding the application of food enzymes*". Dette ser vi som et udviklingspotentiale for kurset generelt.

Laboratoriearbejde

Den teoretiske øvelse forløb fint med god stemning og engagerede studerende. Begrebskortene gav de studerende en repetition af teoretisk stof fra forelæsningen og dermed et overblik over hele emnet *carbohydrate degrading enzymes*. Samtidig gjorde de studerende selv nye opdagelser om sammenhænge imellem de allerede kendte begreber. De studerende kunne på denne måde bruge øvelsen til selvevaluering.

De studerende iagttog ihærdigt deres eget arbejde undervejs og det fungerede rigtig godt at de kunne se diskussionen udforme sig på tavlen. Til tider var snakket meget "nørdet" hvilket sikkert ville have tabt de "svage" studerende, hvis man havde taget snakken i laboratoriet uden et begrebskort. Idet emnet er meget komplekst, mener vi, at visualiseringen kombineret med dialog medvirkede til en dybere læring i modsætning til tidligere års mere overfladeprægede læring (Schwartz & Bransford 1998).

Igennem øvelsen ønskede vi at få svar på om de studerende forstod teorien og samtidig om de blev bedre til at træffe de rette valg i forbindelse med laboratoriearbejdet. Vi observerede halvvejs igennem øvelsen (da kortet var nogenlunde på plads) at de studerende begyndte at referere til deres eget projekt og arbejdet i laboratoriet. En pegede på en pil i skemaet "*det er jo det vi håber på at få svar på i vores forsøg!*".

Endnu et mål med øvelsen var at få alle de studerende – ikke kun de "stærke" – til at deltage i den fælles diskussion. I modsætning til en forelæsningssituation har man mulighed for at involvere alle i den faglige dialog når der kun er tale om fem i en gruppe. Vi fornemmede hurtigt at et par af de studerende tøvede med at tage tuschen og skrive på begrebskortet, hvorefter vi besluttede at tuschen skulle gå på omgang ved bordet. Erfaringen her må være at rammesætning og styring af øvelsen er vigtig.

Overordnet mener vi at et af de vigtigste aspekter ved øvelsen var at de studerende til sidst gav udtryk for at være vældig tilfredse med dem selv og deres egen læring. En udbrød "super – I get so smart".

I forbindelse med vores inddragelse af konceptet, *Laboratory openness*, oplevede vi god respons. "*I really liked that we had to design our own experiment, very fun and I learned a lot.*" (Bilag A). En anden kommentar i evalueringen giver udtryk for at de projektgrupper, hvor muligheden for selvstændig projektudvikling ikke blev udnyttet gav anledning til frustration blandt de studerende: "*Regarding the project work a number of improvements could be made: - We were told that we had the option to come* *up with projects ourselves, in reality it was not an option though. Which gave us students false hope.*"

Til gengæld har den selvstændige tilgang til laboratoriearbejdet også nogle faldgruber: "*The amount of time for the laboratory work is rather limited, 24 hours in total. My group ended up spending roughly 36 hours. I find it highly disrespectful to expect us students, considering that we might be following other courses, to just stay for longer*" (Bilag A). Vi mener, en bedre rammesætning og forventningsafstemning kan være med til at løse dette problem. Og som en studerende foreslår, kunne dette evt. gøres i plenum undervejs i forelæsningsrækken: "*Maybe a short lecture on how to plan a project and what typical mistakes are seen*" (Bilag A).

Igennem dette undervisningsforløb mener vi at have konstrueret både forelæsningen og laboratoriearbejdet som en blanding af teori og praksis. De 2½ time i undervisningslokalet indbefattede teoretisk undervisning med løbende studenteraktiverende opgaver samt case-arbejde. Ligeledes blev en teoretisk øvelse inddraget under laboratoriearbejdet. Ifølge litteraturen kan læringsudbyttet påvirkes af rækkefølgen af teoretisk og praktisk undervisning (Bransford et al. 2000). Vores erfaringer fra dette kursus har dog vist at det ikke nødvendigvis er rækkefølgen der er vigtigst, men nærmere at benytte en kombination af de to undervisningsformer igennem hele forløbet.

Konklusion & perspektivering

Overordnet fik vi positiv respons på brugen af de pædagogiske værktøjer vi havde udset os; inddragelse af læringsmål, dialog, aktiviteter og problemorientering i forelæsningen, samt brugen af begrebskort og gradvis øgning af selvstændighedsgraden i laboratoriet.

Vi ser dialogen, både ved forelæsningen, casen, vejledningen i forbindelse med laboratoriearbejdet og øvelsen med begrebskort, som det vigtigste værktøj til at gennemskue hvor de studerende mister sammenhængen mellem den teoretiske viden og det praktiske arbejde. Igennem dialogen formåede vi at bygge bro imellem de studerendes faglige forudsætninger og vores faglige forventninger, hvilket har været en faldgrube ved tidligere års undervisning.

På baggrund af bedre kvalificerede spørgsmål fra de studerende ved dette års forelæsning, case og laboratorieøvelse i *carbohydrate degrading enzymes*, er det vores indtryk, at de studerende opnåede en dybere forståelse af emnet i forhold til tidligere år. Ydermere er det vores opfattelse at de havde nemmere ved at behandle teori og resultater i deres rapporter. Generelt var de mere selvstændige i læringsprocessen og deres faglige selvtillid voksede tydeligvis undervejs.

Fremover vil vi fastholde de ved dette års undervisning implementerede værktøjer og udbrede disse til vores øvrige undervisning.

Feedback fra faglig vejleder (Lektor Birthe Møller Jespersen, KU-FOOD)

Det har været meget positivt og inspirerende at være faglig vejleder for Mette og Mette i forbindelse med det pædagogiske arbejde om kurset *Food Enzymes and Applications*. Efter flere år hvor den røde tråd i undervisningen om *carbohydrate degrading enzymes* ikke har været tydelig, er det meget inspirerende at se, hvordan hele undervisningen er blevet løftet ved at være bevidst om:

- læringsmål
- aktivering af studerende
- kompetente undervisere

Jeg er enig med beskrivelserne og konklusionerne ovenfor og vil arbejde på at fastholde denne undervisningform i *Food Enzymes and Applications*.

Samtidig vil jeg arbejde på at udbrede den pædagogiske virkning af tydelige læringsmål og aktivering af studerende til andre kursusansvarlige og undervisere - eksempelvis ved præsentation af dette undervisnings-setup ved et sektionsmøde. Der er ingen tvivl om at dette kan forbedre undervisningen og læringen effektivt.

A Kursusevaluering (2015) (NFOK14021U)

Statistics

Results: Food Enzymes and Applications B3-3F15

Statistics Skema A

25 could answer this evaluation form
15 have answered this evaluation form
60.00 % answer percentage: (15/(25)) * 100

Skema A: 7.5 ECTS credit course

1	**My average weekly workload on this course was (incl. lessons, preparation, written work, etc.):**		**(15 answers)**
	Less than 10 hours	3	20.00
	10-15 hours	2	13.33
	15-20 hours	7	46.67
	20-25 hours	2	13.33
	More than 25 hours	1	6.67

Skema A: Course Evaluation

1	**Given my background, the academic level of the course is:**		
	Far too low	0	0.00
		4	26.67
		10	66.67
		0	0.00
	Far too high	1	6.67
2	**In my opinion, the workload on the course is:**		
	Far too small	0	0.00
		2	13.33
		11	73.33
		2	13.33
	Far too large	0	0.00
3	**I believe that I have acquired the competencies described in the course objectives**		
	Totally disagree	1	6.67
		3	20.00
		4	26.67
		5	33.33
	Totally agree	2	13.33
4	**In my opinion, the individual subelements (lectures, exercises, etc.) of the course were logically connected**		
	Totally disagree	0	0.00
		3	20.00
		6	40.00
		5	33.33
	Totally agree	1	6.67
5	**In my opinion, the teaching material was relevant to the course**		
	Totally disagree	0	0.00
		1	6.67
		5	33.33
		8	53.33
	Totally agree	1	6.67
6	**In my opinion, I have received relevant academic feedback on my oral and written work on the course**		
	Totally disagree	2	13.33
		5	33.33
		5	33.33
		3	20.00
	Totally agree	0	0.00
7	**In my opinion, I have had access to the necessary information about the course**		
	Totally disagree	0	0.00
		0	0.00
		3	20.00
		8	53.33
	Totally agree	4	26.67
8	**Overall, I find that the course has been useful**		
	Totally disagree	1	6.67
		4	26.67
		4	26.67
		5	33.33
	Totally agree	1	6.67

What was good about the course? Why? **(15 answers)**

- [redacted] forventede vi havde viden om slagtning. Den ligger meget langt væk og gjorde artiklen til casen uforståelig [redacted] holdt en virkelig kedelig forelæsning. Man skulle ikke tro han faktisk var interesseret i emnet eller at formidle viden.
  Gruppe oplæg med [redacted] var meget intimiderende med hende der trak et æggeur op for at holde tiden.
  Kulhydrat forelæsninger var rigtig gode. Super vi ikke behøvede at lave alle "falling number" – experimenter igen igen.
  [redacted] skal være venlig at skrive større og mere tydeligt samt beskrive hvad de forskellige "bogstaver" står for. Ellers super fint
  Super med masser af information om kurset og opbygning. Dog vær opmærksom på at alle ikke tjekker mails ofte. Nævn gerne vigtige informationer til forelæsning også.
  Første practical aflevering endte med rigtig meget dobbeltarbejde med navne på afsnit, intro, purpose, materialer osv. Meget blev omskrivning og det lærer jeg ikke noget af.
  Kunne være fedt med en forklaring omkring hvorfor vi skal lave en "paper". Hvad er formålet?
- It was/is interesting to plan and do our own project.
  Great trip to Novozymes.
- The materials are all compile in the compendium. So, it is easier to read and understand.
- Practicals and the final paper. Because i believe experience in a laboratory is fundamental to concretely connect the theory with the practical enzyme application.
- Over all I found the lectures to be great, I really like that we had lecturers from different departments of FOOD lecturing the different subjects. Ie. [redacted] who is an expert in Trans Glutaminase. Also it is great having people from the industry doing lectures, ie. the lecturer from Dupont that talked about enzymes in the baking industry was really good.

  I really like the idea that we have a months worth of project work.

  Mettes lecture, and the way she structured it was absolutely great! Probably my favourite lecture.

  The very thorough course plan, and the fact that almost all lecture slides etc. was made available from the beginning.
- workload is just right
- Excursion to Novozymes, get insight to the industry
- I really liked that we had to design our own experiment, very fun and I learned a lot. The excursion to Novozymes was really fun.

I would like to propose the following improvements **(15 answers)**

- Ovenstående..
- Maybe a short lecture on how to plan a project and what typical mistakes are seen.
- Some of the literature are out of date. For instance the literature about the use of enzyme.
- I am sure that [redacted] has the best of intentions, but I really do not think that she is the best at communicating Science. While I know she is the course responsible, and I appreciate the efforts made in putting together a very thorough course plan etc. I do not think she should be lecturing. I really like when the lecturer asks questions, but when the questions differ so much in difficulty it easily confuses the students. While I can not name the specific example, during one of her lectures [redacted] asked a question similar to "Which letter comes after A in the alphabet?" and then followed it with a question like "What is the weight of the sun?" five minutes later, this was during the first or second lecture, and we were really unsure if she actually expected us to be able to answer her second question after having barely been introduced to the course.

  The practicals were not very time consuming, and had we started at 8 thursday morning I am sure that it would have been possible to do both of the practicals in one day.

  The two laboratory reports from the practicals should just be required in order to be allowed to pass the course, and should not count as part of the final grade, just like in any other course that we have had on the bachelor.

  This would leave room for an oral examination.

  I suggest that you have a talk with [redacted] from Quality and Control, he tested a new type of exam in the Chemometrics course last year, which worked really well.

  Throughout the course 4 cases were prepared by the students, the students were put in new groups for each case. The case work was submitted as 5 slides, the lecturer then did a case presentation, where some of the best and worst slides from the groups were discussed, and the given group got to explain/defend themselves. For each case, each group had to evaluate another groups presentation and write 1-2 pages of comments, these were then sent to the respective groups. For the exam, a paper based on the 4 x case comments each student had recieved. Given the nature of the course, each student then had to come up with a new model or a new way of interpreting data in some of the cases.

  The following oral exam was then based on the paper which the examiner and censor had read through. And then spread to cover the rest of the course curriculum.

  Regarding the project work a number of improvements could be made:
  - We were told that we had the option to come up with projects our selves, in reality it was not an option though. Which gave us students false hope

  - The project groups are too big, in my group we are 5, which means that during most of our labwork we are two people looking over the shoulder of two people actually doing something. 2-3 people in each group would be much better.

  - Regarding the projects, I felt that there were too many dairy related projects. While I know that the enzymes are the focus, it always helps if the student can relate.

  - The amount of time for the laboratory work is rather limited, 24 hours in total. My group ended up spending roughly 36 hours. I find it highly disrespectful to expect us students, considering that we might be following other courses, to just stay for longer.

  - With the limited amount of time for lab work, the project framework should probably have been a bit more rigid. While I like that we have choices to make in regards to the experiment design, it is problematic when you end up spending 5+ hours, of the limited 24 lab work ours, on working out how to conduct experiment xyz, and discussing experiment design with supervisors and lab technicians.

  Regarding the first lecture where we had to present our selves. I am unsure of the purpose of this. Is the purpose is to adjust the academic level based on how much experience we have had with emzymes? Is it because the course is usually populated by alot of foreign students? Because it seemed without purpose to have the students, of which at least 60% were students from FOOD, present that we had all had the same courses in biochemistry etc.
- uncomfortable classroom
- - More case studies regarding the application of food enzymes.
  - All the reports should either be handed in as a group report or handed in individually.

Part IV

Challenges of interdisciplinary teaching

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From Fragmentation to Congruence - Designing an Interdisciplinary Project Course

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In the last six years the faculty of the University of Copenhagen (UCPH) has increased its staff of temporary teachers (such as PhD's, Postdocs and external lecturers) from 36% to 67% (Baggersgaard 2015). This has probably had a profound, but still largely unrecognized, impact on the quality of teaching, especially for many of the newly established interdisciplinary educational programmes in which research-based teaching and continuity are thought to be of high importance.

This text aims at describing and analyzing my personal experience with this development. I will show how difficult it can be to design a good interdisciplinary course from scratch when you "come in from the cold" and have little or no experience with neither the educational programme nor the staff involved. I will also try to show how team-teaching together with an experienced teacher does not necessarily solve all problems, and how an interdisciplinary agenda creates several additional challenges to think about.

My main message will be that course alignment is the most important aspect to watch out for when designing a new interdisciplinary course (Biggs & Tang 2011*b*). However, alignment is not only about establishing a constructive link between learning goals, teaching methods and assessments, It also includes inquiry into student backgrounds, ongoing negotiations of learning expectations, the existence (or rather non-existence) of faculty support, and the activation of tacit knowledge among colleagues. In the literature this nexus of teaching and learning environments has been coined 'congruence' (Hounsell & Hounsell 2007), which will be my continuous guidepost by which to analyze my experiences and think about future improvements.

Background

Having worked as a journalist for many years and having experienced a profession in decline, I decided to go back to academia in order to teach and do research in my areas of interest. Soon I got a Postdoc position in interdisciplinary education and subsequently was asked to participate in the development and teaching of a new third-semester course called 'Interdisciplinary Project Course' (IPC) at a newly established two-year Masters programme (MSc) on Climate Change at the Faculty of Science, UCPH. With a PhD in complex systems and some practical experience in climate communication, my background was certainly not ideal for such an assignment.

So here I was. Back in the ivied halls and no clue. Luckily I wasn't all alone. The teacher who approached me for the assignment offered to team-teach the IPC course. This was a great help. We had a few meetings for planning and allotting the course tasks. As teammates we decided to be both present in all lectures, but to share the lecturing so that each of us would plan and teach what we knew best. But still: With a feeling of being marginally qualified, with little experience in university teaching, and without much knowledge about the programme or the teachers involved, how should I approach the challenge?

I tried to read everything available on the web and tackle the situation head on. I consulted the official learning goals, which stated to help students with the practical design (e.g. writing a synopsis) on a climate change related research project:

> "*The course aims at developing the students' capacities to formulate, design, plan and document a climate change related project… [Students will] individually or in groups develop their own research projects, with emphasis on the formulation of objectives, research questions, hypotheses, and methodology, including also plans for data collection and processing, modelling etc. These projects will be documented in the form of outlines of scientific papers.*" (UCPH 2014)

This was clearly a methodological agenda. Additionally, I read about the other courses in the MSc programme and decided to follow them online as much as possible. The first and second semesters were structured as large introductory courses dealing with the '*hard sciences*' of climate change and employing more than a dozen of lecturers from various science and economy departments. However, they did not cover much of the 'soft sciences', such as sociology, anthropology, law and philosophy. And since I understood my job to be one in which I offered new methodological approaches and alternative professional perspectives to the problems of climate change, I decided to prepare "traditional" lectures on the philosophy of science, on sociological studies (STS) of climate change, and on systems- and communication theory, again, always related to climate change issues.

Later on, this double agenda turned out to create problems. For example, as soon as the students had settled on a research project to write a synopsis on, my excursions in the philosophy of science and lectures on science communication fell on deaf ears. It turned out that students were much more strategic about their mental energy use than I had expected. Once they knew what project design to concentrate on for their short oral exam, the rest of the course contents quickly felt like fragmented noise without any sense of relevancy for them.

Of course, my stand as a temporary teacher and my lack of experience caused several additional problems. Here a list, compiled from other people's feedback and own impressions:

1) Insecurities made me default far too often into traditional power point lecturing, sometimes exceeding an hour and a half.

2) My lack of (tacit) knowledge about other teachers and courses in the programme caused some misalignments and unnecessary repetitions.

3) Since my teammate knew our students well, I felt i couldn't take time to ask about the student's interests and expectations in the beginning of the course, making it hard for me to assess their competencies and react to their differences.

4) Thus, missing knowledge about student skills and cultural backgrounds caused me sometimes to overdo my teaching efforts - both in terms of contents quantity and level of difficulty.

5) I didn't activate student very much except from good IRP-dialogue chains, making them more passive than necessary.

My team-teaching colleague definitely tried to adjust for some of the problems along the way, but since the course only lasted seven weeks and much preparation had already gone into the design of the course, there was neither much space nor time to change matters.

Some of the above problems are classical cases of constructive misalignments between learning goals, teaching methods and assessment methods (Biggs 1996). And looking back, it is true that I did not fully understand the implications of the research-design oriented learning goal description cited above. Instead of guiding students to choose and develop their own ideas, I saw it as my main job to broaden their horizons with topics they never had heard of. A few students definitely were inspired by this, but many were confused. Next time I will have to clarify that my main emphasis is not on the novel insights as such, but on the differing methodological tools these alternative perspectives on climate change employ in order to reach their conclusions.

In addition, I didn't yet know the tools and tricks of a truly interdisciplinary teaching style. Rather than synthesizing multiple perspectives continuously, my teaching was characterized by a kind of 'serial disciplinarity': a week-by-week change of perspectives, without much integration or bridge building in between. I knew from start this structure was not optimal, but I didn't know how to prevent it from happening.

My team-teaching colleague had some advice in this regard. If you want to be interdisciplinary, he said, you should continuously employ a change of perspective when talking about real life problems. Say, you talk about declining biodiversity. Try to engage student with questions like: "how would an economist look at this problem?", "what lessons would a priest draw from this development?", or "how would a neoliberal politician frame this fact?". These questions create splitting and interference in the normal thinking process, opening the discourse up for discussions about clashing value systems within the disciplines (and partly explaining why climate change is such a difficult problem to address).

Engaging students and colleagues

I will teach the course again next year. Alone. And again as a temporary teacher. Partly in anticipation of my future responsibilities, I interviewed students and colleagues in the MSc programme in order to improve the course and to potentially collaborate with them on the course design and contents next year. Students generally articulated cautious satisfaction with the course, saying that it was a good preparation for the thesis. But they also mentioned that it was "quite fragmented" and that there were "too many lectures". This was something I would have to work to improve.

My interviews with colleagues on the other hand didn't lead to much enlightenment apart from pointing to a few disciplinary 'threshold concepts' (Meyer & Wenger 2003) to integrate into my course . The main reason for the rather lackluster engagement, I believe, is that there is no 'community of practice' (Wenger 1998) in climate change education at UCPH. In other words, there is no active, collaborating environment engaged in the teaching of climate change. The institution has not made any efforts to put support structures in place when initiating the MSc in Climate Change two years ago. Such efforts could have included making sure that interdisciplinary research and education is adequately valued and resourced by management, or by identifying interdisciplinary brokers, helping students to make sense of the overall picture. Most teachers hired for the programme have maintained allegiance to their respective disciplines (as the literature shows they normally do - see for instance (Diamond & Adam 1995, Jenkins 1996). Thus, very often, these geographers, climate modelers, physicists, and economists have an as limited understanding of the challenges of interdisciplinary educations as the students signing up for them.

Designing a congruent course

When there is no community of educational practice to be part of, there cannot be any 'legitimate peripheral participation' (Lave & Wenger 1991) by temporary teachers like me (nor by the many researchers teaching in the programme). Thus, for the next iteration of the course, I will again solely have to rely on my (former) team-mate and my reading of relevant literature.

I will definitely do many things differently. The most important issue to address is the lack of constructive alignment between the learning goals, teaching methods and the exam. I already have written an analysis of this aspect in my CA-assignment for this course, and will, for this reason, not go much deeper into the many aspects of it. But what was interesting to realize when reading the feedback was that a privileged situation like mine (having a good collaboration with an experience teacher) might make it even *more difficult* to reach a common understanding of what the students can, what the course is about, and design it accordingly. In addition, when you come in from the cold like I did, it is not always possible to prepare sufficiently just by reading the course material or talking with your teammate. There is a whole web of direct and indirect influences beyond your control, such as faculty coordination, unknown student aspirations, and evolving negotiations about values by which to judge the learning outcomes.

Such interrelationships might best be described by what Hounsell and Hounsell call 'congruence' in the teaching-learning environments (Hounsell & Hounsell 2007). While constructive alignment simply implies a kind of reverse engineering of class activities through the identification of learning goals and assessments methods, congruence takes into account local constraints and acknowledges the dynamic complexities of student-focused strategies (Trigwell & Prosser 1996).

So, in order to get a more congruent course next time, I wish to concentrate on the following aspects:

1) Take time in the beginning to understand student backgrounds and skills. This will equip me to adapt the curriculum, if needed. I will also take time in the beginning to discuss student expectations. The course is quite different from what they are used to. This requires inclusive negotiations about what the goals are, why they are important, and how to reach them.

2) Focus much more on what students need for their synopsis rather than on explorations of alternative perspectives on climate change. This implies an increasing use of small written assignments about the students' ideas and formative feedback (Black & William 1998, Bloom 1971). If the class is small enough, I will also try to give feedback both extrinsic and intrinsic (eg. both on submitted assignments and through day-to-day small-group tutoring - see (Bound & Falchikov 2007)).

3) Approach the course with a concrete overarching theme, this time the upcoming COP-21 climate negotiations in Paris, creating a sense of relevancy and trans-disciplinarity (which is a term used to describe a type of learning which goes beyond disciplinary boundaries in order to *resolve* real world problems - see for instance (Jantsch 1972) or (Klein 2008)).
4) A greater use of active learning methods (Olson & Riordan 2012, Prince 2004) such as role-playing, problem-based and peer-learning. Con-

cretely, I will facilitate two climate change negotiation role-playing games; create hands on exercises (in communication and systems theory) and engage students in one or two peer-learning situations (Bound et al. 1999).

5) Chop up lectures into smaller (preferably 20 minute) pieces, concentrating on 'threshold concepts' (Meyer & Wenger 2003), and intersperse them with student activities in order to create deeper learning experiences and give space to possible "delayed understandings" (Entwhistle 2009, Scheja 2002).
6) Try to design step-by-step learning progressions through a week-by-week increase in the complexity of research methodologies used by different disciplines. (This part will probably be very experimental, because it might be difficult to assert the existence of an obvious and purposeful sequencing of learning goals across multiple disciplines (Felder & Silverman 1988). Alternatively, I will try to confront students with types of problems which invite an increasingly open-ended choice of methodology.

With these changes in course design I will be able to make progress in moving away from a feeling of fragmentation and towards a sense of congruence. There is still a long way to go, but with more personal experience as teacher and a better integration into the community, I might get there eventually.

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Interdisciplinary Learning: Process, evaluation, and reflection - A preliminary study of the *Communication & IT* study programmes

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Introduction

In recent decades, the theme of "interdisciplinarity" has gained unprecedentedly popularity in both academia and industry, including education policy, practice, teaching and research circles (e.g., Augsburg (2006), Barry et al. (2008), Brewer (1999), Stehr & Weingart (2000)). While increasingly becoming a focus of attention for institutions advancing learning and teaching, such a term is facing multifaceted criticism, challenges, and obstacles in practice (for a review, see Chettiparamb (2007)).

In the process of teaching and learning practices in higher education, in particular, the transferring of the idea or concept of interdisciplinarity into pedagogy requires more than an understanding of the concept (e.g., Chandramohan & Fallows (2008), Kockelmans (2003). For instance, beyond the acquisition of "the integration of multidisciplinary knowledge across a central program theme or focus," Ivanitskaya et al. (2002) underline that the process of interdisciplinary learning begins as students deliberately reflect upon their own ways of thinking and "... apply interpretive tools across disciplines and thereby face their own internal set of implicit theories, assumptions, beliefs, and prejudices." (p. 103). In their critical review of interdisciplinary higher education, Spelt et al. (2009) propose a capacity of "interdisciplinary thinking" "as a complex cognitive skill" of interdisciplinary learning, which includes a range of subskills besides knowledge of disciplinary paradigms and knowledge of interdisciplinarity, such as higher-order cognitive skills and communication skills. Nevertheless, the literature specific to the understanding and practice of interdisciplinary learning is still best described as inchoate. In particular, as Spelt et al. (2009) address, "...interdisciplinary higher education is still being defined *not in terms of what students gain in ability but in terms of its own pedagogical characteristics*" (p. 375, emphasis added). In other words, the way in which interdisciplinary learning is conceptualized and practicing remains largely concentrated on, for instance, curriculum design and teaching quality, instead of the (expected) process and outcome of interdisciplinary learning from students. The latter, according to Biggs & Tang (2011*b*), is instead the most relevant index that evaluates the outputs of the learning process. Against this backdrop, Spelt et al. argue for the need of more empirical studies to explore "...whether the proposed performance view of curriculum design in interdisciplinary higher education does indeed facilitate the achievement of the learning outcome..." (Spelt et al. 2009, p. 376) in practice.

This study follows Spelt et al. (2009) argument and takes the interdisciplinary study programmes Communication & IT (Comm&IT for short hereafter) at University of Copenhagen as an example to investigate the process and outcome of students' interdisciplinary learning practice. Specifically, it focuses on the process and evaluation of interdisciplinary education from student's perspective and explanations for the ways students tend to integrate knowledge in interdisciplinary programs. In the following pages, I first present the general information about the interdisciplinary program. Second, I introduce the method, followed by the discussion. I conclude with my preliminary reflection upon the practice of interdisciplinary teaching and learning.

The Comm&IT Programme

The BA and MA programmes in Comm&IT[1] starting in 2009 and 2012 respectively, are offered by the Department of Media, Cognition and Communication (MEF) in collaboration with the Department of Computer Science (DIKU). As interdisciplinary programmes, they aim at systematically integrating *communication studies* and *computing sciences* for the design and use of new media in the context of real world practices of individuals, communities, and organizations. Students will get systematic knowledge

[1] For the information about the BA program (only in Danish), see http://studier.ku.dk/bachelor/kommunikation-og-it/; about the MA program (only in Danish), see http://studier.ku.dk/kandidat/kommunikation-og-it/.

about computers, construction, operation, and social applications. Meanwhile, they will learn the skills to analyze the communication processes and problems in work and everyday life (for detailed information about the competencies of bachelor students, see *Studieordning for det centrale fag på bachelorniveau i Kommunikation og it: 2014-ordningen*, 2014: 4-5; about the competencies of master students, see *Studieordning for kandidatuddannelsen i Kommunikation og it: 2012-ordningen*, 2014: 5-6). There is *no* essential requirement that students need to have computer background to enroll in the programme. Generally, in each semester the BA programme offers both courses in communication studies and computer science, while the MA one has joint-courses offered by lecturers from both sides. For instance, the first semester in the BA programme consists of the courses "Basic Communication Theory (Grundlæggende kommunikationsteori)" from MEF and "Basic Computer Science (Grundlæggende datalogi)" by the Department of Computer Science.

The Comm&IT Programme is one of few study programmes not only in the University of Copenhagen but also in the world that integrates communication studies, a discipline of humanities and social sciences, with computer science, a discipline of natural sciences. In other words, the program runs across what people normally perceive as "soft science" and "hard science," which makes it largely distinguished from other interdisciplinary programmes[2]. To be clear, both the disciplinary differences between nature science and social sciences and the humanities and the interdisciplinary feature are so explicit that makes the Comm&IT programme deserving of study. Moreover, the program has its first round of graduate students (with 100% employment rate), which also provides an opportunity to have an overview of different cohorts of students.

Method

This study employs focus group and in-depth interview to explore the process, evaluation, and reflection of interdisciplinary learning from students' perspective. Four student volunteers from BA and MA programmes have been recruited based on the principle of voluntary. Two (A, B) are from the second year and one (C) from the third year in the BA programme. One (D)

[2] Some study programmes in Area Studies, for instance, are also called "interdisciplinary programmes," which largely consists of disciplines within social sciences and the humanities only.

from the second year in the MA programme, who also gets her undergraduate degree from the Comm&IT programme. Three of them are female and one male.

I carried out focus group interviews on the following dates and times:

- With students from the BA program: March 20, 12:00-13:30, KUA Room 14.1.42[3].
- With student from the MA program: December 12, 2014, 9:30-11:00, KUA Room 14.4.05.

Both interviews followed the same schedule. I started by introducing myself and the general information of the project. I also guaranteed that the interviews are anonymous and the data should be analyzed carefully and only used for scientific purposes. The student volunteers will also be able to get access to the final report after I finish it. I also provide souvenirs (each around 30 DKK) to interviewees to acknowledge their participations.

Then, I distributed the questionnaires (see Appendix B) that includes five questions and provided the student volunteers 20 minutes to write down their answers. After they finished their writings, I took around 10 minutes to read all their answers and then carried out focus group discussion or in-depth interviews (for the interview guide, see Appendix A) given what they have written down in the questionnaire. I took notes during the whole process. The discussion/in-depth interview lasted for around one hour and was carried out in English. I also asked for the permission to record all the discussions/in-depth interview.

After the focus group and in-depth interviews, I listened to recorded interviews and made the full transcript of the interview. Then I categorized answers, made notes in an organized fashion, and synthesized the findings. Both the questionnaires and transcripts are available upon request.

Findings and Discussions

Given the answer from interviews, there are a few issues as followed that deserve to reflect upon regarding the process, evaluation, and reflection of interdisciplinary learning in the case of the Comm&IT programme.

First, the term "interdisciplinarity" refers to not only a combination of knowledge from different disciplines, but also multiple, different methods

[3] Together with Manpreet Kaur Janeja from the Department of Cross-Cultural and Regional Studies.

and approaches as means of solving problems and answering questions *in reality*. All interviewees pointed out that interdisciplinarity teaches them to approach an issue or a problem from multiple, different perspectives on the basis of different disciplines. As one addressed, "...it [interdisciplinarity] points out the fact that there is not *one* right way of doing things. You always have to evaluate what both/all areas can bring to your field of research." (B, emphasis added) The interviewees also appreciated the benefit to be interdisciplinary. For instance, one mentioned that "...I do not think my [graduate] project would have the same value and perspectives if it was not interdisciplinary." (D)

In particular, one answer about the understanding of "interdisciplinarity" goes as "...working with several areas at the same time; combining different methods from different areas and making them work together; working with several scientific/philosophical culture." (B) Here, such a comprehensive definition demonstrates an advanced epistemological belief that goes beyond "...application of multidisciplinary knowledge to the same relevant context." (Ivanitskaya et al., 2002, p. 109; Jensen, 1990, p. 100). Because, as one interviewee highlighted, the problem in reality is complicated and does not have any discipline-oriented (D). Accordingly, the approach or method should not be limited within one specific discipline or domain. With repeated exposure to interdisciplinary teaching and learning environment, students develop an understanding of the relations among perspectives derived from different disciplines. This understanding underlines a comprehensive means of looking at things or dealing with problems in reality, which always encourages or allows for alternative or multiple methods or approaches (Klein 1990, p. 196).

Second, practice, in particular problem-solving practice, plays a key role in facilitating the achievement of the learning outcome of interdisciplinary. Interviewees underlined quite frequently the benefits from practices – design project in the first semester and internship, for instance – for them to employ what they have learnt to solve "real world problems." For instance, one valued the design project as her "favorite part," "...because it is our first chance to do something which is a mixture of the two [subjects]." (A) Another added that "...the purpose of the [design] course is to go out and do research and implement the research...to rephrase the answer into concrete designs..." (C) By doing so, students combined and deepened their understanding of not only interdisciplinary knowledge but also – and again – interdisciplinary methodologies and approaches. This point resonates with what Biggs & Tang (2011*b*) underline in their work that quality teaching emphasizes student-centered approach and that it is what the student does that matters in the process of quality learning.

Third, there are a few issues that need to be clarified and paid attention to in the specific case of the Comm&IT study programme:

(A) A misunderstandings of quantitative and qualitative methods in terms of different disciplines. Interviewees tended to connect computer science with quantitative methods exclusively and communication studies with qualitative ones. As one claimed, "[computer science]...only talk about number...[communication studies]. . . only talk about people." (A) Similar statement can also be found from B. This is, however, a wrong understanding. Both quantitative and qualitative research approaches have been employed within the broad field of communication research. Similarly, in the field of computer science, taking a cultural, qualitative approach to understand the design of, for instance, interface, is also becoming an emerging phenomenon (Hazzan et al. 2006).

(B) An incomprehensive understanding of pragmatism. Interviewees tended to treat computer science as pragmatic, which aims to solve practice problems in reality (C). Nevertheless, as an interviewee (B) argued, "social sciences can also be pragmatic..." In other words, pragmatism should not be a criterion to distinguish, in this case, humanities and social science from computer science.

(C) A lack of critique/critical thinking towards the idea/term of interdisciplinarity. Especially, this point comes from the interviews in the Universitetspædagogikum pre-project that includes students from another interdisciplinary programme (i.e., Modern India and Southeast Asia, MISA for short). One of the key differences between student volunteers from the Comm&IT programme and the ones from MISA is that, the former did not demonstrate a sort of critical viewpoint towards either the idea of interdisciplinarity or the programme itself, as all of those in Comm&IT – and most of the students in the programme – do not have study experience in other programmes. On the contrary, three out of four student volunteers from MISA had already finished or engaged in one bachelor degree and two of them had even already enrolled in interdisciplinary programmes before. Such experiences dramatically shaped their perception, understandings, and caution towards the idea of interdisciplinarity. Given the rapid development and emerging discussions of interdisciplinarity, it is necessary to include arguments and criticism towards interdisciplinarity to help students establish a comprehensive understanding of the idea of interdisciplinarity. Such discussion will also enable them to think critically about the subject they learn.

Reflection: The *still* relevant role of teachers/teaching in the process of interdisciplinary learning

A key, interesting observation and reflection regarding interdisciplinary learning that may need to take into consideration in future is: *A joint teaching by teachers from different disciplines plays a key role in engaging students in the process of interdisciplinary learning and articulating matters of interdisciplinarity*.

While interviewees acknowledged that they do benefit from interdisciplinary learning and practice, they addressed a common but key issue in this process (e.g., see Spelt et al. (2009)): the difficulty to integrate concepts and knowledge from different disciplines resulting in a synthesized or coordinated coherent whole *by students themselves*. More specifically, interviewees considered the courses at the bachelor program "...still very separate," (A) or "very divided [in terms of the computer part and the communication part]" (B). For one of them, the course on the bachelor level is rather "a combination [of] courses [of communication and computer science]," (D) instead of an integration of disciplinary knowledge from two disciplines. Given her experience as a teaching assistant in one of the master course, D also added that "it is pretty difficult for the students to see the combination [of different disciplines]...from the theoretical perspective." This, as students perceived, is largely because the individual courses in the bachelor programme are still characterized with a strong, discipline-oriented nature (e.g., the courses Basic Communication Theory/Basic Computer Science in bachelor courses[4]) and, more important, teaching/teachers in different, individual courses rarely make connections among them – in particular with those ones in other discipline. Such a situation leads to the fact that multiple perspectives are presented *without* any support from teachers/teaching for the integration of disciplinary knowledge. In other words, students have encountered difficulties in synthesizing and working in different disciplines or across disciplines by themselves. This consequently poses issues for the development of interdisciplinary learning and thinking, leading to the potential danger that all too often a curriculum is called interdisciplinarity when it is actually *multidisciplinarity* (for the differences between "interdisciplinarity" and "multidisciplinarity," see, for instance, Borrego & Newswander (2010)).

[4] D also took one example, i.e. organization communication and computer-supported cooperative work, from the master course to elaborate on this point.

This is to say, that teaching maintains a *key* role in the process of interdisciplinary learning, as students need specific help from teachers/teaching activity in order to engage in this process and to be able to synthesize two or more disciplines. For the courses in an interdisciplinary programme such as Comm&IT, according to one interviewee, the fact that one teacher taking charge with a whole course "...does not make sense." (D) One possible solution, as currently in the master course[5], is to have teachers from different disciplines working together as a team in a course (D). As one interviewee said, "...the combination [of different disciplines] in the master level is more clear [than in the bachelor level], because we also have teachers, professors, from DIKU and MEF, in one course… so in their work they have to combine it, the way they teach us, to make it clear for us...it was difficult at then [in the bachelor course] to see how they [the courses] clearly match..." (D) Here, teacher/teaching remains an essential but unusual role in the learning process, in particular regarding synthesizing different disciplines, because the teachers themselves are requested to be "models" for the students to understand interdisciplinarity. Such a request thereby to a degree raises the demand for teachers, as they should not only have knowledge in other discipline[s], but also work collaboratively to facilitate the achievement of learning outcomes in interdisciplinary programmes. In fact, there are already several projects running as the interdisciplinary collaboration between MEF and DIKU[6]. To utilize and incorporate current or established research collaborations as part of teaching will be a possible way to advance the process of interdisciplinary learning. In short, realizing desired learning outcomes demands consistent and well-designed teaching and learning environments within a coherent and student-centered curriculum.

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[5] Another example is a course called "Medieværk (in English: Media as Communicative Network)," which I will teach together with a colleague from DIKU in the 2015 spring semester.

[6] See http://ccc.ku.dk/research/

Bigandt and Taina Bucher for distributing calls for volunteers from MEF; Kirstine Dahl for her valuable comments; and student volunteers from the BA and MA programmes Comm&IT, without which this project will not be able to go ahead.

A Interdisciplinary Learning: Process, evaluation, and reflection(Interview Guide)

1. Educational Background/Experiences[7]
   a) Why did you decide to join this programme?
   b) What coursework have you done/are you doing at the moment? How you are going about that?
   c) *What do you understand by interdisciplinarity?
   d) What have the teachers/programme highlighted as interdisciplinarity? Is it different from your current understandings of interdisciplinarity?
   e) Is the experience of studying with students from other similar fields (e.g. Film and Media, Cognition and Communication, etc.) different from the experience of studying with students in the same field? If so, how?
2. Self-Perceptions/Understandings of Interdisciplinarity
   a) *Why do you think you are engaging with interdisciplinarity?
   b) How do you think the (interdisciplinary) programme you are currently enrolled on differs from a field specific programme vis-à-vis curriculum, research, and career placement/future prospects?
   c) Do you think interdisciplinarity is important? Why or why not?
   d) Where did you come across the idea of interdisciplinarity?
   e) *Do you think your understandings and perceptions of interdisciplinarity have changed? If so, how and why?
   f) Why do you think the teachers on the courses/programme are encouraging you to adopt interdisciplinary approaches?
   g) Do you like what the teachers have explained to you so far?
   h) *Do you think you benefit from interdisciplinary approaches/methods?
   i) *Do you think the interdisciplinary programme you are on makes a difference to your study methods?
3. Is there anything else you would like to understand about the interdisciplinarity?

[7] This interview guide and the follow-up questionnaire are developed on the basis of the ones for the pre-project for Universitetspædagogikum "Interdisciplinary Learning: Processes and Outcomes" by Jun Liu and Manpreet Kaur Janeja. The questions that have been included in the questionnaire are marked with an asterisk.

B Interdisciplinary Learning: Process, evaluation, and reflection (Questionnaire)

1. What do you understand by interdisciplinarity?

2. Why you think you are engaging with interdisciplinarity? Why or why not?

3. Do you think your understandings and perceptions of interdisciplinarity have changed? If so, how and why?

4. Do you think you benefit from interdisciplinary approaches/methods? Why or why not?

5. Do you think the interdisciplinary programme you are on makes a difference to your study methods? Why or why not?

Part V

Scientific reading and writing

26

Investigating the level of support for student learning in scientific writing

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Background

The course "Plant Genomics" is aimed at second year undergraduate students from Biology-Biotechnolgy, Agriculture and similar study programs. The course consists of different modules covering different aspects of plant genomics. I was involved in teaching one such model on tracking gene expression over the course of 1.5 weeks in the spring of 2014. The module consisted of lectures, laboratory exercises and a report written by the students. While we had provided the students with some questions to be answered in the report, we had not given written, detailed instructions on the form and the content of the report. We had expected that the students knew how a scientific report should be written at this point of their studies. However, from the reports handed in, it was clear that this was not the case; the quality of the reports was poor, they lacked content and depth. Talking to the other teachers in this and similar courses, I found out that they had experienced similar things. To understand the reason for this, I decided to assess the students' view on report writing and if they possess the expected prerequisites to write a report as we expected them by conducting student interviews. The outcome of the questionnaire pointed towards that we had overestimated students' abilities in scientific writing at this stage, something that was already clear from the reports we received. Therefore, I revised the questions to be answered in the report and wrote additional guidelines for the students to follow in order to be able to write a report at the scientific level we expect of them.

Introduction

Science education often involves practical laboratory exercises, where students conduct experiments following given instructions, and afterwards write about the experiments and their outcomes in a report. One idea behind having students write is to facilitate the construction of scientific knowledge and the development of students' scientific literacy (Keys et al. 1999). Having to find the right language for what they want to communicate will make students reflect on the meaning, at the same time as the meaning becomes clarified through the language (Keys 1999). As scientists they will have to communicate their research via writing, following the conventions of their field, and it is as students they learn how to do this.

Applebee & Langer (1983) liken the learning of scientific writing to a child learning to speak. In order to develop language, it requires scaffolding provided by the parent (teacher) which helps the child (student) to complete tasks which it could not complete successfully on its own. In school learning this scaffolding comes in the form of lesson structures, framing of exercises and textbook materials, and the teacher's comments and discussions. The scaffold gives a secure environment for the student to learn the new strategies and patterns, so that he will not need the scaffold for similar future tasks. When using this approach, Applebee and Langer give three steps the teacher must follow:

a) Determine the difficulties that a new task is likely to pose for particular students.
b) Select strategies that can be used to overcome the specific difficulties anticipated.
c) Structure the activity as a whole to make those strategies explicit (through questioning and modelling) at appropriate places in the task sequence.

In laboratory courses, students meet several kinds of report writing. Often the early laboratory reports are tightly structured, the kind of "fill in the blanks" or with many closed questions looking for specific answers. While this form of report provides scaffold for students to deal with new content, it focuses the students' attention on isolated aspects of knowledge and does not help students to reflect on new ideas, or to integrate and apply them in new ways and make them their own (Applebee & Langer 1983). On the other end of the scale, we have the open format, where no scaffold is provided and the students are expected to deliver both form and content. According to Applebee and Langer this form of writing is good for assessment but not for instruction, as the students' task is to recite material which they have already mastered and not to explore new and more difficult forms. In between the "fill in the blanks" and the completely open format there is a gradient of closed to open report forms.

In order to determine the level appropriate for the students of Plant Genomics, I investigated how students perceive report writing at different levels. Finally, I made some changes to the instructions for the report writing, taking the level of support the students require at this stage into consideration.

Methodology

A questionnaire about lab report writing was designed and distributed to volunteering students. The questionnaire asked about the study program and start year as well what experimental courses the students had and questions to the form of reports they had had to write in those classes. Furthermore, if students thought the report form supported their learning and what was their preferred report form and why. Seven students in total participated: five of the students are third year biology-biotechnology students (students A-E), one student is a fifth year biology-biotechnology student (student F), and one student is a fifth year agriculture student (student G).

Results and discussion

The students that answered the questionnaire fall into two categories. Five of them are bachelor students, all in their final year and all studying biology-biotechnology (students A-E). Two are master students, one studying biology-biotechnology (student F) and one agriculture, although this student has a bachelor in biology-biotechnology (G). Table 26.1 gives an overview of the answers from the questionnaire. Many of the students have had the same courses (several of the courses are mandatory courses for the biology-biotechnology program). From the answers it appears that the laboratory reports in the early courses are of a more closed format (type 1 and 2) but some slightly more open formats are also found (type 3), namely in molecular genetics and chemistry, although answers for the latter vary considerably. Laboratory reports in courses for master students appear to all be of a more open format (type 3 and 4), which fits well with the advanced level scientific writing we expect from students at this stage in their education.

From the answers to the question if the report form supported student learning, it appears that there is an overall agreement between report form and students' learning. The only disagreement is mentioned by students C, D and E in courses chemistry and biochemistry. The comment made by E for biochemistry is in agreement with what Applebee and Langer say about "fill in the blank" type of reports, which they say are not helping students to complete tasks more complex than they would otherwise be able to carry out but on the contrary are simpler than what students would normally do on their own. However, the majority of students answered that they thought this report form was appropriate and supported their learning. From their comments it is clear that they see this form as supportive because it asks direct questions of them. It is solid scaffolding, and they feel very safe within it. At the same time A also comments that this type of report does not stimulate reflections, in other words it might encourage a surface learning approach (Biggs & Tang 2011*a*). As teachers we want students to engage in deep learning, and therefore we should take care in formulating questions that include aspects such as describing, explaining, relating, applying and theorizing to allow for such an approach.

Students also answered a general question about their preferred report form. The answers fall into two overall categories, some prefer the more closed and some the more open format. B, C and D prefer closed formats, while A, E and G prefer the more open formats. F comments "*I think it depends on wich [sic] level you are on. In the beginning it is good it is fixed and with questions. The higher level des [sic] more open format. In this way I think you learn the best.*", which is in beautiful agreement with Applebee and Langer's scaffolding theory, and reflects the answers from the other students. B, C and D express that the closed format gives them security. They may not yet have reached a level where they have mastered the scientific writing, and thus they need more support to have room for practice.

B: "*Either to fill in or with lots of questions, so you have the opportunity to consolidate the right things. Good way to give the right problem formulations and methods the right attention.*"

C: "*Fill in the blanks/answers in form of paragraphs in a fixed structure with given questions. I think the important thing is to clarify the pur-*

class	student	type of report	did the form support your learning	comment
Chemistry	A	2+3	yes	Made me understand the chemical reactions and the theory behind
	B	3	yes	I understood the experiments after having written the report
	C	3	no	There was not enough focus on explaining the parts that had been misunderstood. It is more difficult to remember the things you learn from this type of writing.
	D	1	no	
	E	2	yes	It was good, because we learned the things we needed, but not how to write scientific.
molecular genetics	A	2	yes	Lot of questions to help us understand the methods we used in the lab and why we used them. Some of the reports had some quite open questions which made the report more essay like. That was also learningfull.
	D	3	yes	
	E	3	yes	I think it was a good way to learn the supported things, and how to write a report
	G	3	yes	Yes, you allways learn at lot from having to write down your knowledge.
biochemistry 1	A	1	yes	It helped us to understand the most basic parts but it did not make me reflect about the results or methods we used.
	B	1	yes	Good way to learn, in that you are forced to answer relevant/difficult questions
	C	1	yes	It focused only on the most important things, which is nice in a basic course like biochemistry - it makes it easier to remember
	D	1	no	
	E	1	no	I don't like this kind, because i don't think I learn so much as I can.
plant genomics	A	3	yes	Yes, i learned a lot but mainly because i spend a lor of time on the reports
	E	2	yes	It is good to learn all the theoretical because the right questions are given beforehand. But I don't learn how to think critical, because we don't at this type.
Experimental molecular biology	A	2	yes	Yes, there was a lot of questions to help us undersstand all the methods and background and some questions asked to make us reflect . Sum up: really learningfull
	B	2	yes	Good with questions so you are sure to have understood the experiments
	C	1+2	yes	There were different kinds of report forms, but they all focused on the important things we needed to learn from the experimental part of the course. Explanations but not necessarily answers were fiven ->you had to thinkg for yourself -> you learn.
	D	2	yes	
	E	2	yes	Here, the questios are more guiding so we learned how to think critical and how to write a scientific report.
Advanced plant biology	B	2	yes	Good way to learn, in that you are forced to answer relevant/difficult questions
experimental plant science	G	3	yes	
Quality and postharvest biology of plant products	G	3	yes	We wrote an article
thematic course	F	3	yes	Writing the report was a way of putting our learning into context.
Bachelor project	F	3	yes	"Result was" very good, we had also planned the format together
research placement on transposon activation by pathogenic yeast	F	4	yes	Yes for the same reasons as third year comment (thematic course)
special topics on plant transosable elements, biology and epigenetics	F	4	yes	Yes, this was my first comletely letterature based report and making the transition from an introduction to a full report was good to learn.

Table 26.1. Students answers to the questionnaire. Students A-E are third year biology-biotechnology students and student F is a fifth year biology-biotechnology student. Categories for type of report are 1: fill in the blanks (short answers and calculations), 2: write answers in form of paragraphs in a fixed structure with given questions, 3: write report as continuous text after a fixed structure and 4: completely open format.

pose of what you are doing and the rest should be in relevant questions, that make you understand the theory behind. I don't think you learn from writing a continuous text after a fixed structure; it makes you loose [sic] focus on what is actually relevant."

D: "*Not report scheme, but a lot of questions to answer in form of paragraphs in a fixed structure. I think that I learn the best by this.*"

The other two third year students prefer a more open format, but still with some support:

A: "*I like the more open reports (aim, theory, methods, discussion) where you write a continuous text but the report form where you answer questions in form of paragraphs is also good because it can help you to understand details that you haven't thought about yourself. My preferred form is where you have to answer certain questions in the report but the format is open. I think that works really well.*"

E: "I think I would prefer a report as a continuous text with a fixed structure, because I learn most from the feedback, and not so much from the report itself. It's the feedback that shows me how to write and how the structure should be, because I don't notice how the structure is when it only is questions."

Both students appear to be at a more advanced level, they can see that the open format is relevant for them, but they are aware that they have not yet mastered it. For them, guiding questions and feedback from the teacher would probably be good support (Applebee & Langer 1983).

From the students' answers it appears that our original assumptions, that students are able to independently write a report, were wrong. Students at that level need a more supportive structure in which they can practice. Therefore, I decided to revise the instructions for the "tracking gene expression" module of the "Plant Genomics" course to be more supportive.

Revision of instructions for report writing

The teaching material for the laboratory exercise in "Tracking gene expression" contains an introduction to the discipline with explanations of the methods being used. It furthermore introduces a biological case that is used as the basis for the experiment and states the aim of the investigations. Students conducted the experiments and wrote the report in teams consisting of of three to four students. The exercise consists of a wet lab part and a computer exercise. For the wet lab part, some specific questions about the lab work and the results are given that should be answered in the report. The guide for the computer exercise contains stepwise instructions for the data analysis and throughout the instructions, there are questions marked in bold which students should try to answer in the report. We had orally informed the students that the report should contain an introduction, materials and methods, results and discussion. However, most reports we received were poorer quality than we had expected. To improve the learning for the coming students in the course, we will add a description of what we expect of the report in the guidelines, in addition to the inquiring questions that help students to think about what they did in the lab and why and to reflect upon their results. Because the inquiring questions are specific to the laboratory exercise and would make little sense to the reader, I have omitted them here. The section below will be included in the guidelines for the future:

The report should be in the form of a research report and consist of the following sections:

- Introduction
  - Gives background information and ends with the aim of the present study
- Materials and methods
  - Should contain enough information so that other people can repeat what you did
- Results
  - Including figures and tables. Legends have to be sufficiently detailed so that the figure can be understood on its own.
- Discussion
  - Discuss your results. Where your findings as expected? What can you conclude from the results? What went wrong and possible reasons why?
- Conclusions
  * As this report comprises several experiments, it is a good idea to use sub-headings to help the reader follow what you write about.

From answers in the questionnaire it is clear that the students have some ideas about report writing, some a clearer picture than others. Since future students in the course might have different standpoints, we should try to meet them where they are. For this, a teaching session could be dedicated to how to write a report. This session will be dialogue based, requiring the students active participation. Together with the teacher, students should formulate how a lab report should look. This session will hopefully inform about where the students stand and then build up the structure in plenum from there. My idea with this session is also that during the process of describing what a report should contain, students realize that most of them actually know what is required. By formulating the above given guidelines themselves they will also have internalized them more than by just reading them in the instructions for the exercise.

Concluding remarks

Asking the students about their experiences with writing reports in laboratory courses showed that our assumptions about their level were wrong. This also showed that it is important as course teacher to know the levels of ones students to support their learning. Although several groups in “Plant Genomics” handed in reasonable reports and one group even handed in an outstanding report, I believe that by adding a little more structure, more students can reach a higher level of understanding and that the general quality of the reports will be improved. Allowing students to formulate writing in a structured way will hopefully deepen their understanding of both the practical experimental part as well as their scientific writing skills.

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Getting students to read

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Introduction

My project is based on the course "Genome and Cell Biology" in which I teach together with three others (http://kurser.ku.dk/course/lbik10135u/). It is offered in the MSc Programme in Animal Science and MSc Programme in Biology-Biotechnology, however the course is open to everyone who would like to raise their understanding of cell biology to an advanced level. The course is offered in Block 1 and I would like to dedicate my UP project to this course in trying to improve how the attending students prepare for the discussions of a selection of scientifically related articles. The teaching is based on textbook, lectures, poster presentation (group work) and presentation of scientific articles (group work). In the course description, the students are given a content list of areas that this course will cover. These include a wide variety of themes on molecular cell biology such as: Gene regulation, structure of genomes and their content of information, membrane structure and transport, cell cycle control, programmed cell death and autophagy.

This course is mainly aimed at students who are about to start their masters project. The course is organized in such a way that it is highly recommended that the students have previously attended a 7.5 ECTS Bachelor Level Cell Biology course. Students with little previous knowledge are informed that they must be prepared to work hard.

The purpose of this course is to bring students to an advanced level in cell biology. This level allows an easy start on a master's project or PhD project with cell biology content. Therefore the focus is on understanding principles and not on memorizing details since cell biology is an area of biology that evolves rapidly. The textbook, Molecular Biology of the Cell by Alberts et al., forms the basis for lectures and poster work.

Teaching

Besides using the textbook, this course is based three main types of teaching and/or group work:

Lectures:
The course is based on a series of lectures, each devoted to cover a particular area within genome and cell biology. The lectures will involve a great deal of in class problem solving. It is therefore expected that the students are well prepared for the lectures.

Poster work:
Groups of students prepare posters based on original articles in areas selected by the teachers. The posters are printed and presented at the end of the course.

Article work:
Groups of students prepare a presentations on a larger articles recently published in a high impact scientific journal. The articles have been selected by the teachers.

From the course homepage, the students are informed of the intended learning objectives (ILOs) which are the following:

Knowledge:
Describe the genetic and structural elements, genetic mechanisms and cellular communication of living cells.
Describe mechanisms involved in gene regulation in cells.
Display an overview of membrane structures, cellular compartments and transport of molecules between compartments.
Describe cell division, cell cycle control, autophagy and programmed cell death.

Skills:
Analyse and evaluate scientific papers which describe cellular processes of

any kind.
Apply knowledge on the molecular biology of cells in the planning of own experiments.
Communicate know how in English on the structure and molecular mechanisms of living cells.

Competences:
Apply knowledge on the structure of molecular mechanisms of cells to further analyse problems within genome and cell biology. This level allows for an easy start on a masters project or a PhD project with the cell biology content.

Exam: The exam is based on an oral presentation of one of several exam topics. Exam topics are given in good time before the exam so that students have time to prepare presentations of each topic. The topic to present at the exam is determined by lottery at the start of the examination. Following the topic presentation, the examiners will ask questions for the remaining time of the exam. All aids are allowed. Each student will be assessed according to their performance during the exam and given a mark using the 7-point grading scale.

Problems

From my experience teaching the course last year (2014), it came to my attention that most students did not prepare well for the discussions of the scientific articles. As reading scientific articles is an important part of actually doing science, this course is intended to give an introduction to how you read and understand these. The discussions were arranged so that one group would present an article, 12 in all, after which an opposing group would ask questions. Lastly the discussion was to be set free including all students and teachers. However, it was clear that only the groups who were selected to present and oppose the article had actually done the reading which lead to a rather short lived discussion and only few students who actually grasped the concepts of the article. Since one of the ILOs of this course is to give the students some experience in reading scientific articles, I find that we need to establish more interest among the students in order to achieve that.

Aim

In this UP project, I would like to come up with ideas of to how change the current teaching format during the course so that more students end up reading and understanding the selected scientific articles. My current thoughts are that lectures could be aligned with the selected articles. This could be used to create Case Based Teaching and underline how the textbook does not cover all aspects of cell biology. In addition, to ensure that more students prepare for the article discussions I would like to explore the possible use of class preparation assignments. To get a feel for why the scientific articles seem so low prioritized, I would like to interview students from last year's course. This would give me a better understanding of how well the student's actually did prepare for the article discussions, but also their own views on how to improve this. As this course only runs in block 1 and this project is due before that, it will not be possible for me to carry out and evaluate on these ideas. Yet, I will discuss my ideas with my colleagues, utilizing their vast experience in teaching this course and others, and together design some uniform improvements for next year's course.

Preparation for student interview

To get some feedback and ideas to possible improvements to the course, with a main emphasis on the presentation/discussion of the articles, I invited 3 students who all attended the course last year (i.e. 2014). The aim of this interview was:

1. To establish how well the student's prepare for the discussions of the scientific articles: Am I right when I presume that most students do not read all the articles?
2. To understand, from a student's perspective, why preparing for the articles seems to be so low prioritized.
3. What could be done in order to raise the level of engagement in the article discussions?

Since I relied on cooperation from the students, I was aware that starting the interview by accusing the students of not having done the reading would probably only result in an unfriendly atmosphere. Instead I would start off by offering coffee and a cake, and by thoroughly explaining the background for the interview i.e. that the only intention was to come up with suggestions for next year's course.

Interview with students

As expected, all three concurred that reading all the articles was not something that was highly prioritized. Instead, most articles were either completely skipped or only briefly looked upon before attending class. Moreover, it was their feeling that this practice was common among the rest of the students. It should be noted that one student had not understood that it was considered mandatory to have read all articles, which would suggest that a minor part of the students simply do not read because they think that they do not have to. Nonetheless there was a consensus among the students, that there was no risk in not reading the articles and thus no pressure to actually do so. The students also remarked that the scientific level of the articles was very high and demanded a large effort in order to fully understand them. It was suggested that perhaps a more randomized way of selecting who would present the given article would result in more students reading. However, it was quickly agreed upon that none of the three interviewees would have liked to be in a situation where they would have to explain an article for which they had not prepared or did not understand. Instead it was suggested to divide the class into two or more groups, where each group was appointed an article. One or more students from each group would then at random be selected to present the article for the rest of the class. To this idea I pointed out that the intention was for all students to read all articles. From here the discussion went back and forth on how to establish a more positive attitude towards reading the articles so that the reading is done on a basis of “wanting to” instead of “having to”. I explained that for me, the ultimate scenario would be that all students read the articles out of interest rather than being forced to do so. In addition I revealed my thoughts of including the articles, when appropriate, into the lectures, thereby making it clearer as to how they complement the textbook. To this the interviewees responded positively, saying that a brief introduction of the article and how it relates and complements the textbook would almost certainly incite more students to read the articles. Nonetheless, all three students concurred in finding it very unlikely that this alone would result in all students reading all articles.

Personal reflections upon student interview

To summarize, the interview was conducted in a friendly atmosphere and the students were very eager to help out. As described above, the interview revealed that I was right in my presumptions that most of the students did not read all the articles. Since a small fraction of the students could be excused due to not knowing that reading all articles was considered mandatory, we should be more explicit in addressing this at the introduction to the course (this was also pointed out by some of the students in the course feedback; Appendix A). Yet, it was clear that most students prioritized their preparation time on matters that would have the biggest effect on the final outcome at the exam, such as reading the book chapters and preparing their presentations. Clearly the interviewees thought that it would have a positive effect if some kind of pressure was put on the students in order to get them to read all the articles. Although I respect their self-awareness on what works in terms of how they prioritize their preparation for the course, I am reluctant in setting up a system that makes the students read by brute force alone. Instead I was delighted to hear the positive feedback on the idea of introducing the articles in the lectures, which inspired me to rethink how I teach.

For some time, teaching based solely on traditional lecturing has been considered "a thing of the past" and several studies have suggested teachers to reconsider the teaching format in order to improve the way content is learned at a university level (Duffrin 2003). In fact, some studies suggest that lecturing is not a particularly effective way of promoting deep student learning (Bates & Galloway 2012, Chew 2014). Nonetheless, lecturing is still very much the predominant way of teaching at many universities and it certainly also dominated my own way of teaching at the course last year. Based on the input from the student interview, I would like to include the relevant articles into my lectures. Ideally this could be done by introducing a form of Case-based teaching (CBT) which is an active learning strategy where students apply their knowledge and their analytical skills to complex, real-life scenarios relevant to the subject matter. As CBT is considered a useful way to combine traditional lectures with problem-based learning (Van der Veken et al. 2008, Coorey & Firth 2013), I find that it could be helpful for engaging and creating relevance for students to the articles.

Although I am confident that introducing the articles by CBT will inspire more students to prepare better for the discussions, I am aware that this alone is unlikely to get all student's to read all articles. Having to teach students that are not well prepared for class seems to be one of the most fundamental problems encountered when teaching. One approach to increase student involvement, and thereby engage the students in the learning process, is to introduce class preparation assignments (CPAs; (Yamane 2006)).

CPAs are described as regular, low-stakes writing assignments that lead students to critically engage with the primary or secondary sources that constitute the assigned readings. Quite recently this approach was tested revealing that CPAs provide a strong preparatory base for active learning and are effective means of boosting student involvement and comprehension of course material (Davis & Minifie 2013). It therefore seems that combining CBT with CPAs could be an effective way of getting more students to read more articles. This would, however, require a combined effort from me and my colleagues in redesigning the approach to the article discussions.

Preparation meeting for Genome and Cell biology course 2015

To evaluate on last year's course and prepare for the next, I met with my colleagues in the end of June. During the meeting we discussed several matters that lie outside the scope of this project and will therefore not be described in detail here.

On the evaluation of the article discussions I was not surprised to hear that my colleagues shared my concerns that the students in most cases were ill prepared. Based on my informal interview with the students and the official course feedback, we quickly agreed that we need to be more clear in explaining the article discussions format and how well-prepared we as teachers expect the students to be. In addition to this, we will provide the students with a short written guideline which should help them focus on what is important when presenting an article for others and serve as a written explanation on the article discussions format.

While the written guideline would help to ensure that all students are informed on "the what's, the when's and the how's" related to the article discussions, this would not ensure that the students actually sit down and read the articles. I therefore proposed my ideas on CBT and CPA as explained above. These ideas were well received among the other teachers. This lead to the discussion whether we the previous year had been too focused on finding recently published, high impact articles instead of finding articles that would fit better into our lecturing format, complementing or underlining the textbook. It was decided that more focus should be on selecting articles that aligns with the lectures although we still find it important that the articles represent the latest research within their respective fields. In addition to this, we discussed a CPA format where each group would be asked to hand in one question to each article prior to the discussions. All questions should be readily available to all students prior to the discussions, clearly stating who formulated the question and to which article it is related. After the presentation of each article, the groups will be asked to put forward their questions and engage in the discussion. The idea is that no single group or student would like to be associated with tedious or even banal questions. Note that the intention is not to ridicule anyone. Instead, our hope is that this format would create a form of self-discipline among the students, inciting each group to formulate interesting questions that will stimulate the article discussions.

Conclusions

It is clear that when trying to improve any course, it helps when there is commitment to do so from both sides of the teacher's desk. I was therefore very pleased to find that both students as well as my colleagues were so positive in their support of this project. Obviously it remains to be seen whether the implementations of e.g. CBT and CPA will have the desired effects. It is therefore difficult for me to conclude anything on the changes of format that we have decided upon for next year's course. Nonetheless, I have found it very inspiring to interact with the students and my colleagues trying to improve the way I/we teach. One thing I did noticed during this project is that, for me, it is much more interesting to prepare and rethink a teaching format instead of just following "the same procedure as last year" brushing of the presentations/notes/questions from last year and do the teaching from there.

Part VI

Interactive lectures and using ICT tools to promote learning

28

Evaluating Interactive teaching on conceptual understanding on medium enrolment classes

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Abstract

Interactive learning is increasingly being valued as an ideal environment that promotes critical thinking, conceptual understanding, intellectual development and success. The beneficial effects of interactive lectures though very well established for small classrooms are often debated for larger classes. My hypothesis is that interactive lectures can easily be introduced to large classrooms and that students' engagement understanding and academic achievements can be greatly improved by constructively aligned interactive lectures. The purpose of my project is to evaluate the effect of interactive teaching on students' engagement, conceptual understanding, as well as academic achievement and performance on medium enrolment (~55 students) classes. This is particular important for me as up to now I have been successfully implementing interactive lectures in small enrolment classes (<20 students) and now faced with the challenge to teach by myself a medium enrolment class (50 students) of the 2nd year students.

To test my hypothesis I applied a series of actions on the course Nanobio 1 of the Nanoscience education some of which are shortly mentioned here: A) Interview with group of students after the end of the course. B) compare their understanding (using online tools) between subject taught using classical
lecturing/preaching and subjects taught by interactive discussions C) compare students performance (grades) on subjects that are "preached" in the form of classical lectures, subject interactively discussed in the class and

subjects that are both interactively discussed and applied during practical exercises.

My results showed a remarkable increase in correctly answering the exam question, from 45% for subjects only lectured to 70% for subjects interactively discussed and 87% for subjects interactive discussed and applied in practical exercises. Similarly online quizzes using Student Response Systems (SRS) like *Socrative* showed an increase from <30% to often more than 90% in students ability to apprehend and interactively discussed subject and correctly answer a multiple choice question when knowledge is attained in the form of interactive processing of information.

Results and Discussion

Introduction

Interactive learning is increasingly recognized as an invaluable tool in promoting critical evaluation of information and attaining increased levels of conceptual understanding, intellectual development, and success. Most modern textbooks claim that students learn by actively processing the information (Popovic 2013, Cowan 2012). They also show that involvement in active discussions are more likely to stay “on task” and spend more time synthesizing and integrating concepts, relative to students who passively spectate lectures (Cuseo 2007), and importantly develop more positive attitudes toward the course’s subject matter (Cuseo 2007). Interactive teaching strategies however are challenging to implement within the constraints of classical training which in turn increase faculty reliance on classical “lecture” methods. In fact the classical lectures, despite their limited effectiveness, is widely used by many academics to fulfill the mandate for regular didactic sessions on large number of students.

One of the main reasons behind this is often the sheer size and anonymity of large classes that seems to militate against the very elements that promote students’ involvement. In fact as McKeachie (1980) notes, “[Class] size and method are almost inextricably intertwined, large classes are most likely to use lecture methods and less likely to use discussion than small classes”. This consequently causes reduced frequency of instruction interaction and iteratively resulting in less active student and reduced *depth of student thinking* inside the classroom. Importantly it may initiate maladaptive mental habits or predispositions to learning generating passive seekers and transcribers of information rather than critical thinking and inquiring students (Blatchford et al. 2011). But how possible is it to attain all the beneficial results of interactive learning in classrooms with medium to high enrolment? I was recently faced with this challenge as I was assigned to teach full time a 2nd year of the Nanoscience education, Nanobio 1 with ~50 participants. The course was often discussed as needing both to improve its interactive nature and to achieve better student satisfaction. Importantly while I have been 2 implementing interactive discussion in smaller classes (<20 students) I have never had to apply this methodology to medium enrolment classes.

To deal with these objectives I performed 3 actions.

1. Designed and extensively used quizzes that evaluated in real time students conceptual understanding in subjects that were “lectured” or “interactively discussed”. Quizzes were performed using online Student Response Systems (*Socrative*)
2. Designed exam question that targeted subjects that were a) “lectured”, b) “interactively discussed”, or c) “interactively discussed” and directly applied in the practical exercises
3. Formed a focus group of 6 students that were interviewed to provide an elaborate qualitative assessment of their opinion on the methods.

Methods and some details for the course

Online quizzes were valued using *Socrative*. Students were always given multiple choices (usually 5) to choose from within ~3 min. When team discussion was involved time was extended to ~6min. ~2-3 Socrative question were presented to the students per hour of a teaching occasion.

“*Lecturing*” a subject used for the evaluation corresponds to ~15 min of me preaching while showing slides or/and writing on the blackboard.

“*Interactive discussion*” on a subject used here for the evaluation corresponds to ~5 min of providing the basic information (in the form of slides and/or writing on the blackboard) and ~10 min where the student were discussing. Students’ discussion in the first teaching occasions was gently guided by me being part of the discussion and appointing the next person to talk). At later stages (when students got acquainted with the discussion concept) my role was minimized to an observer.

Exam question were designed to target a subject similar to what "lectured" or "interactively discussed" in the class but it was never identical. The exam question always had a sub question for students to explain their choice. Students answering correct and scoring >50% of the total points of the exam question were considered as correct for the purpose of this study while students scoring <50% of the total points were considered as wrong.

In order to supplement the results obtained with the above methods with qualitative feedback, I conducted a 90-min focus group interview with 5 students from the course. They were given o questionnaire of 16 question were they had to provide a short 1-2 sentence answer. Subsequently we started a more in depth discussion of the answer ~5 min for each question. The interview was recorded on an iPhone 6 with the Voice Memos application. After the interview, all comments from the focus group were typed in to an excel spreadsheet. I did not attempt to fully quantify the responses, but have quoted some of the representative comments in the text.

Some more info for the course

6 hours of *teaching occasions* per week for 6 weeks, 2 weeks of *practical exercises* and 2-3 hours of *tutorial* per week for 3 weeks where students were taught to what they needed to write their graded report: a) use online tools to search literature (such as e.g isis web of knowledge) and Endnote to import references in the word files, b) use software to draw protein structures find and highlight positions of amino acids c) how to critically read articles, evaluate and write by themselves abstracts. During teaching occasions Each week students had to deliver a non graded (but compulsory to take the exam) set of problems. Subjects similar to the weekly problems, practical exercises and the *Socrative* quizzes formed the basis of the final exam questions.

Effect of interactive teaching in conceptual understanding and overall satisfaction

Introduction and use of interactive tools and Student Response System in medium sized classes.

The first steps in introducing the interactive discussion into the class were facilitated by the use of *Socrative*. Initially students were called to answer by themselves the quizzes, later on, to discuss in teams of two before answering. Towards the end of the course most student (~50%) overcame the barrier of talking in the class and were contributing actively to the discussion. *Socrative* was used to evaluate (rather than introduce) the 3 results of the discussion. Discussion at this point was either taking place in teams of 3-4 students or in the whole classroom with minimal contribution from my part.

During the focus group meeting students enthusiastically commented on *Socrative* as a tool to both facilitative real interactive discussion and to promote intellectual development. In detail they found it to be "an excellent way to make sure that you have understood the concepts", as "...it anonymously allows the real evaluation" while a third one commented "...it maintains you alerted throughout the lectures but also helps weak students not to fall asleep". A third student noted that "...it eliminates the fear of embarrassment" of not having understood something but feeling too embarrassed to say it.

The fact that ~22% of students (6/26) evaluating the course on Absalon noted that they would like even more (currently 2-3 per hour) *Socrative* quizzes to be implemented in the course shows *Socrativ*e to be well appreciated. These results strongly support SRS tools to be instrumental in triggering students' attention, maintain them alerted and "on task" throughout the teaching occasion time, and last but not least to promote active student involvement and consequently learning.

Role of Interactive discussion in conceptual understanding

Interactive learning environments are widely considered as ideal suited to give students personal validation and frequent feedback on their work, set high expectations and consequently to promote critical thinking conceptual understanding, and intellectual development. Their implementation however in medium to large enrolment classes is challenging and most institutions rely on classical lecturing methods were students are passive spectating knowledge preaching. Importantly the beneficial effects of interactive learning are often questioned in medium/large (>50 students) classes. My hypothesis is that interactive lectures can be introduced to large classrooms and that students' engagement and conceptual understanding can be greatly improved.

To evaluate this hypothesis we performed a direct comparison of student understanding of a concept using *Socrative*. A concept (why the charge of amino acids depend on the pH of a solution) was introduced in to the classroom in the form of a classical lecture. The introduction lasted for ~15min where I presented multiple slides with various ways to evaluate and interpret the concept. Subsequently the students were asked to select the correct answer out of a multiple-choice question quiz using *Socrative*. The data presented in fig 28.1 show that ~46% of the students answered correctly within the first 3 min. As a comparison another – more challenging – concept was introduced for 5 min and then interactively discussed in the class for ~10min (assigning the diastereomers of amino acids with multiple chiral centers). The students were then asked to select for the correct answer out of a multiple-choice question quiz using *Socrative*. The immense improvement in students understanding is highlighted in fig. 28.1 where ~95% of the students correctly answered the question.

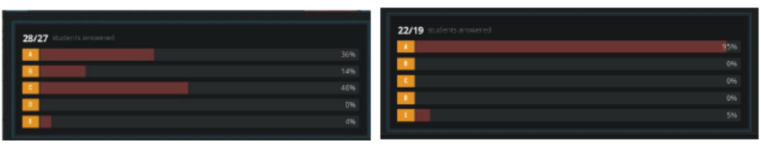

Fig. 28.1. Comparison of level of understanding attained by a) lecturing (~15min) on a subject and b) providing the basis (~5min) and allowing interactive discussion (~10min) for students to understand a different subject.

To further examine the role of discussion between peers in students critical evaluating and understanding concepts we performed another test using *Socrative*. A multiple choice question was posted (fig 28.2ab) were two questions (option A and C in fig 28.2ab were correct and the students were given the option to select each of the correct answers, both (option D), another one (B) or none (E). After selecting their answers the student in teams of 2-3 discussed the answer without any contribution from my part and voted again. Before the discussion only 20% of the students had provided the correct answer (D in fig 28.2a) while 76% of the students had selected the first or the second of the correct answers (A or C) respectively. Remarkably after 3 minutes of discussion with peers 87% of the students answered correctly (fig 28.2b). The same experiment was performed twice (fig 28.2cd) using the same principles on a more challenging concept. In this case none (0%) of the students had found the correct answer (D in fig 28.2c) while 32% and 16% had selected each of the two correct answers.

After the discussion 68% of the students selected the correct answer (D in fig 28.2d).

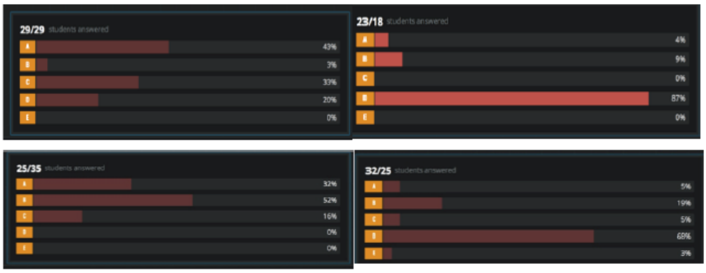

Fig. 28.2. Comparison of the level of understanding after on a subject before (a and c) and after (b and d) discussion with peers. In the first case ~20% of the students responded correct (D option) before discussion, shown in a), while 87% of them responded correct after discussion, shown in b). In the second case ~0% of the students responded correct (D option) before discussion, shown in a), while 87% of them responded correct after discussion, shown in b.

The opinion of students on the interactive lectures was explicitly discussed in the focus group. All participant students agreed on the success of the interactive discussion in attaining critical and conceptual understanding of the principles. They portrayed the advantage of the “non-judgmental” discussing with peers – as compared to the “intimidating” discussion with the professor – in critically evaluating and even doubting the information. As students highlighted “you had to listen to people at your own level and use your own knowledge to doubt and evaluate the information”. A second student found it as being a “non judgmental form of pertaining knowledge” or as another noted “if you said something wrong you were not looked down on you” while a third student found it “... as a good training for the exam as you put your own words in a argument” as compared to just listening and trying to memorize to an argument.

Importantly students highlighted the beneficial effect of direct and active processing of knowledge in mastering conceptual knowledge by saying “in depth knowledge comes when you apply immediately what you just heard/learned rather than have to wait until the exam”.

Students also highlighted that interactive discussions are “inspiring” and “motivating” as one student noted “... I know I can do it, hypothesize a solution/mechanism. This motivates me to fight harder challenges and find my way through this course". Another student also said "(being able to understand and hypothesize solutions)... boosted my self confidence and motivation" something that the whole study group agreed. An another student highlighted its beneficial effect in owning science, "a perfect way to learn new stuff. I think all courses could learn form this. *It felt you were part of the world of science*".

Similar comments and feedback was provided by the students using the absalon online evaluation. "...letting the students participate actively in the lecture is spot on! And the way you are alive and interact with the students is the way to go and make the lecture much more personal". The overall satisfaction of the students is also reflected by their comments on absalon where they used phrases such as "eye opening course" "very interesting and engaging course".

The results of these tests support our hypothesis that *interactive discussions can be implemented in the medium enrolment classes and furthermore so advantageous effect in strengthening student ability to critically evaluate knowledge consequently facilitating deeper, conceptual, understanding and intellectual growth*. In addition it appears to promote students inspiration, motivation and importantly satisfaction of their performance, all of which would propagate to their overall satisfaction of the course and the education system.

Interactive discussions/tools in preparation time and performance in exam

We then examined the role of interactive environment in the reading/preparation hours of the student as well as their level of understanding and performance in the exam. To do this we initially designed exam questions on subjects that were either simply "*lectured*" or "*interactively discussed*" in the classroom (see Methods section for disambiguation). Due to the limited amount of question in the exam only one question for each of the two methods was prepared.

Students severely underperformed in subjects simply "lectured" in the class (phase states of phospholipids dependence on their structure). As shown in fig 3a only 45% of the students (21 out of 46 student that attended the exam) answered correctly in a subject that was "lectured" for 30 min in the class. In comparison ~70% of the students (32 out of 46) responded correctly in an exam question that was interactively discussed for ~30min in the class, fig 28.3b (titration curve of amino acids). These data signify the importance of interactive environment for conceptual understanding though improved statistics would be required to solidify this further.

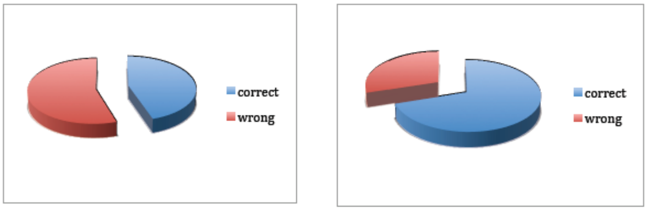

Fig. 28.3. Comparison of students' performance on the exam on subjects a) only lectured in the class b) interactively discussed in the class. The fraction of students that understood the concept and responded correctly in the exam was increased from 45% for a subject taught using classical lecture (phase states of phospholipids dependence on their structure) to ~70% for a subject taught using interactive discussions (amino acid titration curve).

To evaluate the time students spend in preparation for the lectures we interviewed the study group. The study group students had attended more than 90% of the teaching occasions. The results of the interview show relatively high preparation time for the teaching occasion. All (6/6) of student wrote they were prepared for most of the lectures (*almost every time*) while their preparation time was 1-1.5 h and as they noted, "I had to be prepared for the teaching occasions otherwise I was lost".

Importantly the study group highlighted that the *interactive lectures helped them read less for the exam*! The argument of one of the student 4, that all participants of the study group agreed on, was that ".. because we had to be prepared for every lecture, applied and understood the concepts we almost did not have to read any further for the exam."

Our results convincingly support students in interactive courses are forced to invest more time in preparation, directly evaluated and apply attained knowledge committing to deeper understanding of the principles and consequently requiring often less time to prepare and excel in the exam. In total the findings here support interactive teaching to be associated with a host of positive student outcomes on ranging from student attention retention, to critical thinking, and educational aspiration, in agreement with earlier studies(Astin et al. 1997, Lewis 1992).

Constructive alignment on exam performance and general student satisfaction

The role of constructive alignment between theoretical teaching and practical exercises was subsequently evaluated. I particular I was interested in identifying a) the effect alignment of theory and practical exercises as well as team work on students conceptual understanding, intellectual growth and performance in the exam and b) a possible correlation between students enhanced learning and intellectual growth to their overall satisfaction for the course.

To test for these I performed the following actions. A) The protocol for the practical exercises was lacking most calculations of amounts of chemical needed and some details of how to perform the experiments. The way to design and perform the calculations as well as how to logically think, design and execute the missing experimental part had been discussed during the teaching occasions. Students therefore had to simply critical think (in teams) and apply the conceptual knowledge they attained so as to perform the practical exercises. B) Exam questions were designed to target subjects similar to the ones applied in the practical exercises (and interactively discussed in the class). The students scoring on these exam questions was then compared to their scoring in subjects that were only interactively discussed during teaching occasions.

Students of the study group commented very positively both on the alignment of practicals with theory but importantly on their enhanced understanding by having to think in groups. One student found that "everything we needed was built in from the lectures and practical, we learned (by interactive discussions) to deduce/build concepts from first principles". A second student commented that "we actually had to think for ourselves and directly apply the principles we had learned in the course", or another "I actually had to think and was forced to work with every detail of the experiment" while another added, "yes *this was not just a cake recipe but real science*". Importantly students highlighted the beneficial effect of such methodology, as one says "I can remember every details of what we did in contrary to XX course's practical exercises that I cannot remember anything at all", something that all agreed. All students agreed to this comment.

The quantification of the beneficial effect of the critical thinking of the practicals and their alignment with theory was done by the exam results shown in fig 28.4. These show a remarkable increase on the students' scoring on subjects interactively discussed from 70% correct (fig 28.4a) (amino acid titration curve) to >87% correct for subjects both interactively discussed and applied in the practical exercises (fig 28.4b) (michaelis menten kinetics). It should be mention here that the exam question were targeting the conceptual understanding that students should have developed, and they were not a direct repetition of exactly what they did during the practical exercise. Notably, additional similar experiments would eliminate putative variations in the difficulties of questions and strengthen the results here. The overall satisfaction of the student is highlighted by their very positive comments outlined here and the fact that all students wrote that they liked the course (3/5 gave 5out of 5 stars and 2/5 gave 4)).

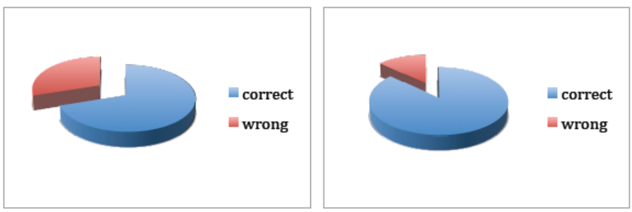

Fig. 28.4. Comparison of students performance on the exam on a concept a) interactively discussed in the class, b) as in (a) but also applied in the practical exercises. The fraction of students that understood the concept and responded correctly in the exam was raised from 70% for a subject taught using interactive discussions (amino acid titration curve) to ~87% for a subject taught using interactive discussions and applied in the practical exercises (michaelis menten kinetics).

These data support that active processing of information significantly augments conceptual understanding. Reading and interactive discussions may provide the strong foundation for deep, conceptual, understanding, but it can – and should be – significantly enhanced when a concept discussed in the class is applied in the in practical exercises. Constructively aligned therefore practical exercises with theory appear as instrumental in promoting intellectual growth and academic achievement.

Discussion with the department Supervisor

The department supervisor, Per Hedegård statistician from Niels Bohr institute, acknowledged the quality of the research the concepts the interpretation and the intriguing results that emerged. The main critical comment of the discussion that we had during the design of the actions, was that the statistical soundness of the exam results (figs 28.3,28.4) would be significantly enhanced by performing the same actions for multiple questions in additional classes, for different levels of the educational system and varying academic fields. This way the potential variation in difficulties between the exam questions used to evaluate classical Vs interactive teaching effect would be eliminated. This valuable comment, though practically impossible to implement within the time and scope of the project, prompted me to design and execute the socrative tests that are discussed in figs 28.1-28.2 here (note that data are presented in reverse order in the project description). The two tests of fig 28.2 evaluate in the same question students understanding before and after interactive discussion. Though enhanced statistic would further solidify these data they augment our confidence that interactive teaching increases student understanding in medium enrolment classes.

Conclusions and Perspectives

Active involvement in teaching occasions seems to make the course engaging and motivating triggering students' inspiration and excitement. Interactive discussions were found pivotal tools in *combining* students' own knowledge to *criticize* and *compare* the information provided by their peers allowing them to *hypothesize* and *formulate* their own arguments. This is highlighted both by the *Socrative* quizzes and the exam results illustrating dramatic enhancement of students' performance in conceptual understanding on subjects interactively discussed into the classroom. Though more robust statistics would be required to further solify the observed trends our results do show subjects taught by interactive lectures to be unequivocally better understood by the students since 70% of them answered correctly in the exam as compared to 45% on subjects taught by lecturing/preaching. Students recognized the advantageous effect of formulating their own arguments as a good practice for the exam. Importantly alignment of the practical exercises with theory further enhanced students understanding scoring ~87% correct answers in the exam, highlighting that further – critical – processing of information in the form of group aligned practical exercises is an elemental tool in attaining fundamental understanding.

Our result in summary support student faculty interaction to be strongly associated with a host of positive student outcomes ranging from a) student retention, (b) academic achievement, (c) critical thinking, and (d) educational aspiration (Astin et al. 1997, Lewis 1992). It may now be time to apply the principle of interactive learning to the redesign of teaching methodologies, creating more opportunities for students to indulge in critical discussions evaluating and perpetuating knowledge provide a learning environment that is conducive to both student engagement and student success.

It may now be time to apply the principle of interactive learning to the redesign of teaching methodologies, creating more opportunities for students to indulge in critical discussions evaluating and perpetuating knowledge provide a learning environment that is conducive to both student engagement and student success. We may thus replace mediocre student performance and passive knowledge seekers to critically thinking inquiring engaging minds predetermined to achieve academic and professional success.

A (Interview questions of the study group)

1. How many lectures of Nanobio 1 did you attend ?
2. I liked the Nanobio1 1 course (1-5)
3. I think that Nanobio 1 was interactive (1-5)
   Why (2 sentences)
4. I liked the socrative quizzes
   (why)
5. I liked the discussions taking place into the Nanobio 1 (1-5)
   why
6. The "interactive teaching" influenced how I studied (1-5)
   How
7. How often did you prepare for the nanobio 1 lectures
   a. Every time
   b. Almost every time
   c. About halph of the times
   d. Few times
   e. never
8. How long was the preparation time for each lecture (if/when you did so)
   a. 0 h
   b. 0.5-1h
   c. 1-1.5h
   d. 1.5-2h
   e. .2h
9. The "interactive teaching" helped me to better understand new concepts (deep understanding)
   Why
10. I think that the course teaching occasions, discussions practical exercises and exam were well aligned. (1-5)
11. The overall design of the course (interactive and alignment) inspired me to actively engage in discussions (1-5)
    Explain
12. The "interactive teaching" helped me to be better prepared for the exam
    why
13. In lab exercises the protocols required some work form our part in contrast to other course that they are very well defined. I liked that (1-5)
14. The design of the lab protocols helped me to understand better the lab exercises and the concepts behind them (1-5)
15. In comparison with other lab practical exercises (other courses) with very precise protocols I have learned more (1-5)
16. I wish this type of interactive teaching would be applied in other courses

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Enhancing student learning with case-based teaching and audience response systems in the MSc. Course “Food Innovation and Health”

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Introduction

As many people of my generation, I am mostly familiar with a “teacher-centered” approach to lecturing, in which a teacher is expected to deliver a content so as to cover a course curriculum. To a large extent, lecturing is still the dominant teaching method in most higher learning institutions, and often – due to habit and ignorance of alternative approaches – the only method adopted at all (Gibbs 1981, Mazur 1997). It is certainly easy to see why lectures are popular: they are time and cost efficient, and they give the teacher full control on the content (Bates & Galloway 2012) giving that comfortable feeling that “the ground has been covered” (Schneider 2007). Unfortunately, there is plenty of evidence suggesting that lecturing is actually not a particularly effective way of promoting student learning (Bates & Galloway 2012, Chew 2014, Trigwell et al. 1999).

After joining the teacher development program at University of Copenhagen, I have had the chance to reflect at length about my own teaching, and think about ways to move towards more interactive, student-centered approaches. Luckily, much has been written on classroom techniques to engage students and achieve more effective teaching and better learning experiences. The purpose of this paper is to share an example of how two of them – the use of case-based teaching, and the use of response technologies – were implemented into a food science M.Sc. course, and to discuss some of the observed outcomes.

Classroom techniques promoting student activation

Case-based teaching

Many studies suggest that educators should move away from traditional lectures and focus on improving the way content is taught and delivered in higher education courses (Arámbula-Greenfield 1996, Duffrin 2003, Mazur 1997). Case-based teaching (CBT) is an active learning strategy in which students apply their knowledge and their analytical skills to complex, real-life scenarios relevant to the subject matter. In general, CBT is considered a useful way to combine traditional lectures with problem-based learning (Coorey & Firth 2013, Van der Veken et al. 2008), as it emphasizes social interactions between students, and the development of learner autonomy and learning situations that resemble those relevant to the profession. Accordingly, the use of case studies has been found helpful for engaging and creating relevance for students (Duffrin 2003), and for helping the students to organize and identify gaps in their knowledge (Stern 1996).

In CBT, students are introduced to complex situations requiring a decision. Such situations can be real (e.g., examples from past or current research) or just realistic, and can vary in degree of complexity. The development of a case study should start with identifying a set of key concepts that the students should rely on, and careful consideration should be given to their potential to achieve learning outcomes (Duffrin 2003). Students are often asked to work in groups and to evaluate each others' opinions before any plenum discussion takes place. Working in groups can help students develop interpersonal skills and the capacity to work in a team, and accordingly CBT contributes to raise student's ability to communicate about a topic (Coorey & Firth 2013). After considering the case at hand, students (or groups) are asked to make a statement about their suggested solution to the case. The teacher in this case can facilitate a classroom discussion by asking questions to probe the reasoning behind the suggested solutions, and ask other students to evaluate them. Assessment of case studies is usually offered at the end of the class discussion and, depending on the format, can be used for both formative and summative purposes (Biggs & Tang 2011*a*).

In general terms, cases are especially useful to assess the application of concepts to appropriate professional practices. By placing them in real situations and asking them to take decisions, case studies help students to connect their knowledge with their decision-making skills, as well as to distinguish high-priority elements from low-priority ones. Indeed, compared to lectures, cases are a much better way for the teacher to see whether students are able to apply the knowledge they have been studying.

The available literature on CBT specific to food science education is limited. There are a few notable exceptions (e.g., Duffrin (2003), Coorey & Firth (2013)), that suggested that CBT be more widely adopted in food science education, given that the applied and interdisciplinary nature of the field is very well suited for a problem based approach.

Audience response systems

Another helpful strategy to improve student engagement is the use of audience response systems (ARS), technologies that allow an entire classroom to respond to various questions projected on a screen using a remote control device, with real-time visualization of results (Bruff 2009, Caldwell 2007, Greer & Heaney 2004, Kay & LeSage 2009)[1]. ARS are usually associated with relatively large class sizes and with multiple-choice questions, though applications in smaller audiences and with different question formats are also found (Kay & LeSage 2009). Student responses can be stored (anonymously or otherwise) and used for both summative and formative assessment by the teacher. With real-time feedback from the classroom, ARS provide teachers the opportunity to facilitate a discussion about the concept being covered (Kay & LeSage 2009). Some teachers like to combine ARS with the peer instruction format, in which students answer the question, then discuss their answers in pairs or small groups, and then answer the question again (Mazur 1997). The use of ARSs in higher education was originally limited by technology, but has become increasingly widespread due to the development of free web-based ARSs which allow students to easily answer questions with their own devices (laptops, tablets, smartphone, etc.). ARSs are associated with a number of benefits. Among other things, they have been found effective for improving student interaction, activation, and attention (Draper & Brown 2004, Hinde & Hunt 2006, Greer & Heaney 2004), stimulating peer and class discussion (Kay & LeSage 2009, Pelton & Pelton 2006), enabling formative assessment (Caldwell 2007), improving student learning (El-Rady, 2006), and increasing classroom attendance (Bullock et al. 2002). Students and teachers who have used ARSs are generally positive or even enthusiastic about their effects on the classroom,

[1] ARS are also known with a variety of synonyms in the literature, e.g. “clickers”, “computerized voting systems”, “student response technologies”, etc.

and there is wide consensus that these technologies have great potential for improving student learning (Beatty 2004, Caldwell 2007).

Course details and learning outcomes

"Food Innovation and Health" (FIH) is a thematic M.Sc. level course taught at University of Copenhagen, Denmark. The course typically enrolls 15-20 students, with a background in human nutrition, food science, or home economics. Most of them take the course as part of the eponymous MSc. Program[2], an interdisciplinary program focused on food product development and combining knowledge of human nutrition, food chemistry, culinary techniques, sensory science, consumer behavior, innovation and entrepreneurship. FIH is the last course students take before their thesis work, and is designed for the students to build on previous knowledge acquired in the first year of the program.

The objective of the course is to provide students with knowledge of practical food production and innovation, with a focus on palatability and health in food products as well as in meals.

The course starts with a confrontation-intensive period, which covers the first three weeks. In that period, teaching takes place 4-5 days a week. For the rest of the block students work in groups and organize their time independently. The course is very popular and well evaluated, and it was elected by the students as best course of the faculty of Science in 2012, and was runner up for the same prize in 2013. The main reason why this course is so popular is most likely the extensive project based phase where students develop, test and pitch actual food products, based on challenges from food companies or other organizations. For example, this year's students worked on making snack bars using brewers' spent grain, examined gastronomic strategies to masking boar taint in entire males meat, and developed a non-alcoholic drink based on Nordic ingredients targeted at restaurant goers.

Table 29.1 summarizes the course overall learning outcomes:

[2] MSc. Program in Food Innovation and Health: http://studies.ku.dk/masters/food_innovation-and-health/

Intended learning outcomes for M.Sc. in "Food Innovation and Health"
Knowledge
1. Experience with ideation and business model generation for developed food products.
2. General knowledge of basic operations and tools for gastronomic food production.
3. Innovation, intra-, and entrepreneurship in relation to foods.
4. Describe carbohydrates, lipids and proteins basic function and characteristics in food and point out the effects of culinary processes on physical, chemical and sensory conditions of food components.
5. Adapt methods of preparation for different raw materials based on a rational gastronomic foundation.
6. Reflect on the nutritional aspects of raw materials and their changes in culinary processes.
7. Pointing out the essential microbiological risks connected with especially low temperature preparation methods and the necessary precautions for handling raw material.
8. Describe the effect of physical processes such as pressure treatment and freeze-drying on the structure of food and how physical treatment can be used for developing gastronomic dishes.
9. Give an overview over aesthetics in relation to food, meals and eating.
Skills
10. Use techniques to foster innovation and creativity related to development of new foods.
11. Production of prototypes of complex foods, production in pilot scale of complex foods, including demonstration of practical abilities with culinary techniques.
12. Consumer tests of complex foods.
13. Reflection upon own development, and ability to see opportunities and the potential for students' professional competences in intra- and entrepreneurship and innovation.
14. Work in a gastronomic laboratory with chosen experimental techniques and culinary methods.
15. Communicate in writing the topics in the gastronomic area with regard to innovation in foods.
16. Integrate aesthetics in relation to food, meals and eating.
17. Communicate gastronomic concepts to professionals and relevant employers/purchasers.
Competences
18. A scientific approach to food innovation and small scale food production.
19. New Product Development of healthy and palatable foods.
20. Integrate academic disciplines (food chemistry, sensory science, and nutrition) to innovation and business development in the food sector.
21. Use and adapt techniques for characterization of sensory properties and consumer experiences.
22. Interdisciplinary cooperation with other students on planning, carrying out and evaluating experiments in relation to new product development of healthy and palatable foods.
23. Work independently and efficiently together in a group on joint projects.

Table 29.1. Overall course ILOs. The ones most related to my own teaching are italicized.

In this course, I teach about sensory science, which is the discipline concerned with measuring and understanding responses to food properties as perceived by the senses such as sight, smell, taste, touch and hearing (Martens 1999). Sensory science has many applications in the food industry: it can be used to evaluate whether there exist a perceptible differences between two stimuli (e.g., the same product stored at different temperature), to quantify specific properties in a food sample (e.g., its sweetness, its color, or the hardness of its texture), or to evaluate the hedonic value of foods and beverages (e.g., quantify the degree of liking or whether a version is preferred over another). Given the breadth of application, different sensory methods exist depending on the project purpose, the type of assessors available, the magnitude of differences between stimuli, and on other practical considerations. Furthermore, data sets resulting from sensory tests can be quite large, and can often present peculiar structures. Multivariate data analysis methods can be very useful in the exploration of the structure of such data (Dijksterhuis 1995).

Normally, most students will have at least some prior background in sensory science from previous courses. However, their practical experience with sensory science is limited (sometimes none, which is often the case for exchange students, or of students enrolled in other programs that take the course as elective). Essentially, my role in the course is to teach students about different sensory evaluation methods that can be used in a product development context, and how to match the right methods to available resources and the specific problem at hand. I also teach about sensometrics (statistical analysis of data from sensory experiments) in relation to different type of data. This can be expressed into two main intended learning outcomes (ILOs):

ILO 1 (*sensory methods*): the students should identify existing sensory methods and their requirements, and to select the right method in relevant situations;

ILO 2 (*sensometrics*): the students should be able to arrange and perform appropriate statistical analyses on data from different sensory methods.

Implemented changes in teaching approach

I am responsible for four "lectures", with a main confrontation time of 8 hours. The first lecture focuses on sensory methods (ILO 1), the second on practical planning of sensory tests (ILO 1), the third on data analysis or *sensometrics* (ILO 2), the fourth is a tutorial on specific data analyses using sample datasets (ILO 2).

Previously, my teaching approach has been pretty much lecturing. Although I generally receive good end-of-course evaluations, I have often wondered about the effectiveness of my lectures.

This year I implemented a change of lecture format in the direction of CBT, thinking that the applied nature of the course would lends itself very well to the purpose. I thus devised a series of activities based on actual examples from ongoing research or from literature. The goal was challenging students with a scenario where they needed to apply their knowledge of the subject matter, while providing them with immediate feedbacks on their learning (Mazur 1997, Schneider 2007).

Essentially, I structured the lectures such as it consisted of short presentations (20 min) about a central point, followed by a case study related to the points being presented, which the students were invited to think about individually or in group. I have used a variety of approaches to activate students, some of which based on ARSs, and experimented with several formats (group and pair discussions, multiple choice questions, open-ended questions, etc.), as this is advised for providing a refreshing variation and to increase student's attention (Schneider 2007). Some of the activities were especially inspired by Eric Mazur's concept of peer instruction (Mazur 1997, 2009). Peer instruction (PI) is built on the idea that better learning can be achieved if the students actively discuss the subject matter with their peers instead than if they just listen passively.

Regardless of the format, the common goals of these activities were that they (1) should engage students and make the lecture more student activating, and (2) that they should provide opportunity for formative assessment, either by making students discuss their understanding with their peers (peer instruction), or by allowing me to modify my explanations or way of delivering the content according to the class discussion.

First example (ILO 1). My first lecture concerned sensory methods and their applications. I introduced briefly the classification of sensory descriptive methods in *verbal-based*, *comparison-based*, and *reference-based* Varela and Ares, 2012). Instead of providing examples of application, I thought placing the students in the position of a sensory lab manager having to decide the best course of action would be a more effective learning experience. Therefore, I developed a series of case studies in which the students were asked to determine the best sensory methods based on the three central aspects in any sensory study: the purpose of the project, the difficulty and number of samples, and the type of panel available for the job (Table 29.2). Basically, the students were given the case study individually for a minute or so. Then, I asked them to speak to their neighbors and convince them or their answers for about five minutes. Afterwards, to nudge the discussion towards some critical aspect, I also gave them an "extra hint"[3], and provided a few more minutes to reconsider their assessment

[3] For instance, Case 3 was about municipal water, which is relatively difficult to describe from a sensory point of view. The hint indicated that there are some known key parameters for water taste quality, and that therefore a method based on comparison with references – say, two samples representing an acceptable range of salinity – might be a good choice in this case.

of the case. Finally, I reviewed the problem together with the students. In this case, I opted for a plenum discussion format because of the classroom size ($N = 15$), but also because all cases had more than just one possible solution. In doing this, I tried to facilitate further peer assessment (e.g. orchestrating a discussion between groups to argue against/defend their suggested solution) before getting to the "institutional" point of view, i.e. offering my own assessment of the case.

Case 1: **"A new sea-buckthorn juice"**	**Case 2:** **"Common roasting defects"**	**Case 3:** **"The taste of water"**
Purpose: Developing a new sea-buckthorn base beverage together with a local producer. The goal is to obtain a sensory description of the samples and also identify preferred prototypes.	**Purpose:** A small coffee producer wants to investigate the effect of common roasting defects on the final sensory quality of their coffee.	**Purpose:** Assessing the sensory quality of Danish municipal water.
Samples: 8 prototypes developed by blending sea-buckthorn juice with either apple juice or orange juice.	**Samples:** 6 (1 reference + 5 common defects).	**Samples:** 10 water samples collected at 10 different locations in Denmark.
Trained panel available: No.	**Trained panel available:** No, but company wants to train own employees (12 potential assessors) for that purpose.	**Trained panel available:** Yes (10-12 trained judges).
Extra hint: Both sensory and preference data are needed…	**Extra hint:** Coffee temperature rapidly decreases…	**Extra hint:** Previous studies suggest that the level of salinity (Na concentration) and the total amount of dissolved solids (TDS) are important parameters…

Table 29.2. Three examples of case studies discussed in class (from actual recent/ongoing projects in my group).

Second example (ILO 1). A second example concerned the practical planning of sensory science experiments. This lecture is very fact-based and the background literature covers very straightforwardly principles of good practices required for this type of experiments (e.g. experimental design and treatment structures, sample preparation and serving procedures, ISO standards for sensory evaluation facilities, panel screening, selection, and training, and legal aspects/requirements for using humans as subjects of sensory tests (Lawless & Heymann 2010). To increase students' activation, I decided to use again CBT, this time using the ARS "Socrative" (*MasteryConnect* 2014). The cases were meant to illustrate practical considerations during planning of sensory studies, and varied in format (multiple choices, true/false, and open ended). A sample from the case studies is shown in Figure **??**.

1. Identify whether the case described below has a sensory analytical or a hedonic character. Motivate your choice by suggesting which method to use. "A brewery wants to test if consumers can taste a difference between a freshly brewed beer and a beer that has been stored for some weeks. Both beers are pasteurised and have been stored in dark-brown bottles."

(A) Discriminative
(B) Descriptive
(C) Affective (hedonic)

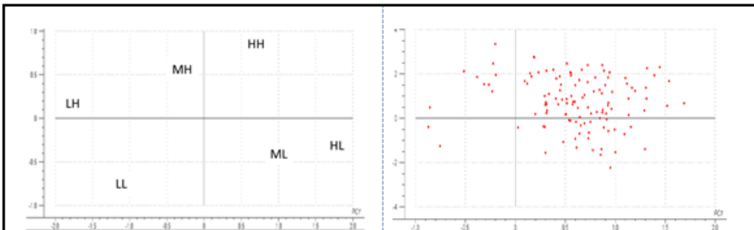
2. Identify whether the case described below has a sensory analytical or a hedonic character. Motivate your choice by suggesting which method to use. "A brewery wants to test if consumers can taste a difference between a freshly brewed beer and a beer that has been stored for some weeks. Both beers are pasteurised and have been stored in dark-brown bottles." They decided to go for a duo-trio test. Could they have chosen a paired comparison test instead?

(A) Yes
(B) No

3. Identify whether the case described below has a sensory analytical or a hedonic character. Motivate your choice by suggesting which method to use. "A brewery wants to test if consumers can taste a difference between a freshly brewed beer and a beer that has been stored for some weeks. Both beers are pasteurised and have been stored in dark-brown bottles." They decided to go for a duo-trio test. How can the sensory manager at the brewery increase the reliability of the test?

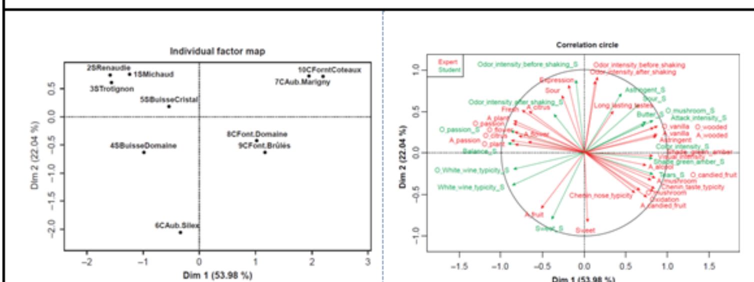
Fig. 29.1. Examples of case studies used in relation to ILO 1. Correct answers (Q1:A; Q2:No, because paired comparisons assume prior knowledge of the nature of the difference); Q3: Several possible answers, e.g., improve statistical power, increase number of tests/subjects, select more sensitive subjects, provide training, etc.).

Third example (ILO 2). A third example concerned the data analysis methods (ILO 2). Teaching data analysis to students without a firm grasp on statistics (often the case in particular course) is always a challenge. The risk that the students will adopt surface learning strategies is much higher than for other parts of the curriculum. I wanted to use apply CBT learning in statistics, as students are more motivated and better understand concepts when real data sets are used. I also wanted to structure my student activation activity around visual results interpretation, both because this is the key skill students will need when communicating the results from sensory tests to other professionals, and because visual explanations have been mentioned to be very effective in food science education (Schmidt 2009). In order to do that, I developed a series of concept tests based on different plots form multivariate data analyses of sensory and consumer science data. They were designed so that the students would learn how to interpret and draw conclusions multivariate plots. The students discussed the cases with their neighbor, and then a plenum discussion followed.



Background. EU project focusing on reducing the sugar content in apple juice (Rødbotten and others, 2009). Sensory testing of apple juice from concentrate. Six samples were developed by adding water, sugar and acid, following 2*3 factorial design, with three levels of sugar (H, M, L), and two levels of acidity (H, L). Samples were tested by 126 consumers (nine point hedonic scale), and the data analyzed by Principal Component Analysis (80% variance explained in the first two components).

Q1. Which samples are most different?
Q2. Which sample(s) seem to be most liked?
Q3. What seems to be the main 'driver' of liking?



Background. A sensory profiling of ten Loire Valley wine, conducted by a panel of trained assessors and a panel of food science students (Pagès and Husson, 2009). Samples 1-5 are Sauvignon, S6-10 Chenin; Samples 7 and 10 are aged-casked (woody taste), Sample 6 has high residual sugars (10 g/l).

Q1. What seem to be the main sensory differences between the samples?
Q2. Are the two panels describing the wines similarly?

Fig. 29.2. Two examples of case studies discussed in class

Fourth example (ILO 2). The idea with this test was for the students to think about different data structures resulting from sensory experiments. For each of them, they would indicate the most appropriate data analysis method among those covered in the course, using a multiple response question format in Socrative. The key elements that the student would have to consider in this task were essentially two: (a) the number of data matrices (one, two, or more than two), and (b) the type of data (quantitative or categorical) obtained in the study. The goal of the exercise was for the students to work out those essential elements during the task. Ideally, there is a simplified decision tree one can use (which I in fact used to summarize the discussion after the task).

1. Q1. Researchers at UCPH ran a study to investigate the effect of cooking time and temperature on the sensory properties of beef cooked sous-vide. Three different cooking temperature (56, 58, and 60 degrees C) and four cooking times (3, 6, 9, and 12 hours) were considered producing 12 samples in total. The data consists of a sensory evaluation by a trained panel, averaged over assessors and replicates. Now you want to use a MV to visualize the main differences in sensory properties between your samples and assess the effect of time and temperature. Think about how the data would look like, then indicate what MV method seems most appropriate. NB: more than one answer may be correct..

(A) Principal Component Analysis (PCA)
(B) Correspondence Analysis (CA)
(C) Partial Least Squares Regression (PLSR)
(D) Multiple Factor Analysis (MFA)

2. Q2. You are the panel leader of a sensory lab running a project about chicken meat fed with 4 different feeding strategies.You run a sensory profiling with 10 sensory panelists in triplicates. Now you need to explore the data and to find out out whether the feeding strategies affect the sensory quality of chicken meat. At the same, you want to evaluate whether your panelists are generally agreeing with each other, and whether the different replicates produce the same results. Think about how the data would look like, then indicate what MV method seems most appropriate. NB: more than one answer may be correct..

(A) PCA
(B) CA
(C) PLSR
(D) MFA

3. Q3. Together with a small local producer, you are working on a project developing new fruit juices based on nordic ingredients. You are asked to provide reccomendations based on sensory insights. You set up a large consumer test (N=200) where consumers report their liking for the juices and also describe their sensory properties by a CATA questionnaire. You want to visualize the sensory properties of the juices and relate this information with the preference data. Think about how the data would look like, then indicate what MV method seems most appropriate. NB: more than one answer may be correct..

(A) PCA
(B) CA
(C) PLSR
(D) MFA

4. Q4. You are running a study investigating chemical and sensory properties of apples with different storage time (10 days and 20 days at −0.5 °C) and regimes (air vs controlled atmosphere). The data consists of some physico-chemical data (volatiles analysis, firmness, % solubles solids, etc) and of sesnory assessment by a trained panel. You need to analyze the data in order to determine the relationship between sensory and instrumental parameters and the influence of storage period and storage atmosphere on the chemical and sensory composition of the apples. Think about how the data would look like, then indicate what MV method seems most appropriate. NB: more than one answer may be correct..

(A) PCA
(B) CA
(C) PLSR
(D) MFA

Fig. 29.3. Example of case studies used in connection to ILO 2. Correct answers (Q1:A; Q2:D; Q3:B,C,D; Q4:C,D).

Assessment of teaching effectiveness

Considering the limited class size, and the even smaller number of students who completed the evaluation survey, I relied on both formal and informal assessments of my teaching approach, such as:

1. My own reflections and observations;

2. Quantitative course evaluations by the students;
3. Critical feedbacks provided by my pedagogical supervisor and the course coordinator, who sit through some of the lectures;
4. Insights from a focus group I conducted with a subset of students ($N = 7$), shortly after the end of the course.

Student evaluations for the course were generally very good (Figure 29.4). The applied aspect of the course and the real world relevance was mentioned as the most significant positive aspect of the course. Some comments raised during the open-ended online evaluation and the focus group interview were:

- really applied course with interesting projects;
- so much fun! Both with the kitchen exercises and the project work. It is nice to be able to use the knowledge from my previous courses in FI&H - everything comes together in this course;
- it gave us the opportunity to work on a real case scenarios;
- the course rounds off perfectly what we have learned during the MSc programme. Very exciting and relevant.

All of the student who completed the online evaluation totally agreed with the statement that participation in the course was a “rewarding” experience (Fig. 29.4).

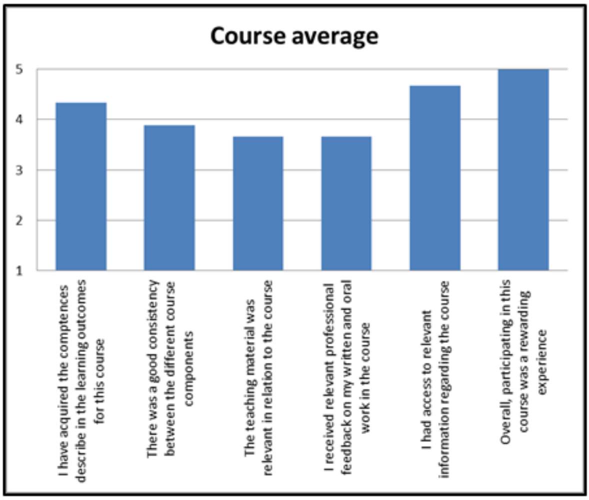


Fig. 29.4. Average student evaluations of the course (Likert scale, 1=Totally Disagree, 5=Totally Agree).

Regarding my own teaching, my overall impression is that CBT worked very nicely in activating the students and shifting the focus from lecturing to a more student-oriented way of learning. This was no doubt facilitated by the applied focus of the course and the small class size.

The activities that had a peer instruction component (e.g. Example 1) were particularly successful in engaging the students and the discussions between neighbors were surprisingly animated. As a teacher, I tried to facilitate the plenum discussion and to fully discuss each point of view before moving on to the next exercise. Actually, a “mistake” I found myself doing a few times is giving too quickly my own assessment of the case, before having exhausted the arguments from the students. As soon as I did that, all potential for further discussion was quickly lost because of the institutional aspect involving in the teacher speaking. In hindsight, I wished I had resisted the temptation to end the ambiguity, and given the students more time to discuss the issues that were raised. It is well known that less experienced teachers may have need some time adjusting to students feedbacks (Kay & LeSage 2009), so I think more experience with this teaching style will certainly help with pacing the discussions. On the other hand, including a peer instruction part (which I know worked well in engaging the students

– the class size was small so it was easy to eyeball the interactions), could be useful in making sure that students achieve the right level of activation.

Regarding the use of ARS, it was clear that the students liked it a lot and found it very entertaining. There has been some questioning in the literature whether or not this positive attitude towards ARSs, which is often reported, is associated with actual learning (Kennedy and others, 2006). In the more quantitative question formats, students responses were extremely good so that suggests that there was at least successful in solidifying concepts presented in the lecture. Although ARSs are obviously more beneficial in larger classroom, I will continue to use them as students liked it and it has the additional benefit of enabling summative assessment.

Overall, the students gave good evaluations (Figure 29.5), and the focus group interview suggested that the teaching format was effective in reaching the learning outcomes:

- Socrative was nice and useful also to make it in more entertaining;
- Very nice with Socrative!
- Case studies very useful;
- Some overlap with sensory science teaching in previous courses, but good to get the basics;
- Clear approach to choosing methods, good decision path, was easy to match methods with goals b/c of the teaching;
- Statistics is a difficult topic, but cases helped making it understandable.

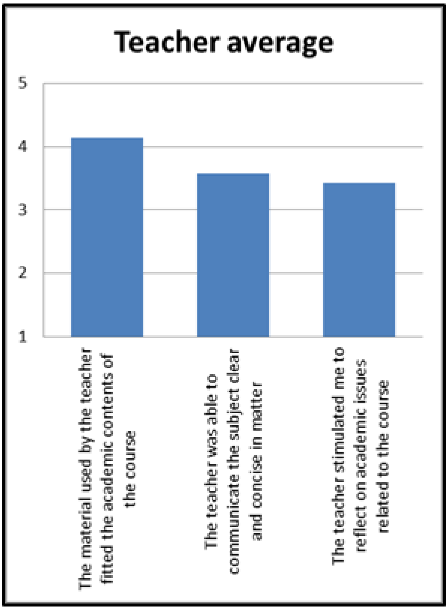


Fig. 29.5. Average student evaluations for my teaching in this course (Likert scale, 1=Totally Disagree, 5=Totally Agree).

Among the most interesting suggestion for improvement during the focus group was that I should avoid long lecturing streaks, and getting faster to the part where "they do something". I was both pleased and surprised to hear this comment, which all students present at the focus group seemed to subscribe too. Pleased as this suggested that the students liked the changes towards active learning, surprised because these were the classes were I lectured the least ever!

Conclusions

This project focused on the use of CBT and ARSs into a food science M.Sc. course. It was observed that the particular initiatives were very effective in engaging student participation and promote a more active way of learning. STR further facilitated class discussion, in addition to providing a real time of assessment of the teaching effectiveness. Both the use of CBT and ARS were well received by the students and were facilitated by the applied profile of the course. Creating and implementing these activities has required a substantial effort (especially relative to a normal lecture), but eventually it has been a most rewarding experience after witnessing their potential in enhancing the learning of my students.

Acknowledgements

I am grateful to the teachers, staff, and fellow participants from the *Teaching and Learning in Higher Education Programme* at University of Copenhagen. Prof. Marianne Ellegaard (Dept. of Plant and Environmental Sciences, University of Copenhagen) and Dr. Michael Bom Frøst (Dept. of Food Science, University of Copenhagen) are thanked for sitting some of the classes and providing excellent feedbacks.

30

Improving learning in large classes with online quizzes

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Abstract
In this project I address the problem of teaching mathematics to a large class of first-year students in life sciences. I focus on the introduction of quizzes during the lectures (clickers) and online quizzes for self study. The motivation to introduce quizzes is discussed, the practical aspects of the implementation is presented, and their effect on the students' learning is assessed.

Formulation of the problem and hypotheses

Course and class description

The project concerns the course *Mathematics for Biologists*. This course is a first year course of the bachelor in Biology at the University of Copenhagen, consisting of about 3,75 ECTS. The course is part of a 7,5 ECTS course called *Mathematics and Statistics*. The statistics part runs independently of the mathematics part. However, the students obtain one mark for the combined course and they need 50% of the points in the combined exam to pass the course. That is, they are not required to pass the exam in mathematics and in statistics separately.

There are about 230 registered students, and a prerequisite is to have passed mathematics at A-level in high school.

In the course 2014/15, the subject was taught for 7 weeks, with two 2-hour lectures (except for the first two weeks, when there was only one

2-hour lecture) and one 2-hour exercise session per week. In the exercise sessions the students were divided into smaller groups and were given time to work hands-on on some exercises related to the content of the lectures and lecture notes.

Foreseen problems

I taught this course for the first time in the course 2014/15. Therefore, my understanding of the challenges with the course was based on collected information from the experiences of the teachers of the previous years and from dialogues with other first-year teachers of the bachelor in Biology.

The foreseen problems with the course can be summarised as follows:

(i) Lack of *engagement*, *motivation* and understanding of why it could be relevant for them to learn mathematics. The self-reported time dedicated to the course in the previous years was on average far from expected.
(ii) Lack of *mathematical skills*, specially on basic arithmetics learned in primary school.
(iii) Lack of *understanding* of the new material.
(iv) Lack of independence in learning and responsibility over their own learning.
(v) Lack of awareness from the teacher perspective of the student's learning.

Engagement and motivation in the classroom is associated with increased learning (see e.g. (Fredricks et al. 2004) for a study concerning learning in schools). The first day of the course the students were asked to answer three simple questions, aimed at verifying the extend to which problem (i) was a problem.

Questions:

(a) Are you happy about learning mathematics at the university?

Yes:	51%
No:	22%
Indifferent:	26%

(b) Do you understand why you should learn mathematics at the university?

Yes:	86%

No:	6%
I don't know:	9%

(c) What is the grade you expect to obtain in this course?

0:	5%
2:	12%
4:	18%
7:	31%
10:	18%
12:	15%

My interpretation of these results is that, *a priori*, the students were more positive about the course than what I would have thought. It was surprising to me to see that the expected grade actually follows a normal distribution.

Although it is not the university the place where problem (ii) should be fixed, it poses clearly a real problem when learning new mathematics. Therefore, it cannot be completely ignored under the excuse that *this is not my problem*. However, the content of the course cannot be changed to simply cover things the students should already master.

Problem (iii) stemmed partly from problems (i) and (ii), but I believed that it could also be a consequence of the format of the teaching activities, mainly the lectures. The students are not used to mathematics being taught in a lecture format and find it hard to relate to that[1].

Achieving independence in the learning process (problem (iv)) should be one of the learning outcomes of any bachelor. Hence it is a skill that should be trained in all subjects of the bachelor. However, I considered that independence in learning mathematics is not an expected skill of any biologist. Therefore, instead of focusing on helping them to be independent, I focused on removing the necessity of independence to master my course.

Finally, problem (v) is expected when teaching large classes in large auditoria, where direct contact with the students is reduced to small conversations during the breaks and the teacher can hardly get a clear picture of how the class is progressing.

[1] Some students expressed they could not believe that this is the usual way of teaching in the bachelor in mathematics as well.

Introducing quizzes

The course was reformatted in content and teaching approach. In particular, I introduced quizzes in two formats: during the lectures and online for self study.

Evidence on the benefits of IT-learning are diverse and documented (see (DeHaan 2005) for a summary). For this specific project, the rationale behind the introduction of quizzes during the lectures and for self study to address problems (i)-(v) is the following:

- For problem (ii): Questions involving basic mathematical skills can be introduced in quizzes for self study, thereby helping the students refresh their knowledge from primary and high school and, at the same time, not interrupting the flow of the lectures or exercise classes for the students that have the required background.
- For problems (iii)-(iv): Quizzes during the lectures are a way of introducing active learning in the classroom, an aspect known to increase learning outcomes (Freeman et al. 2014). Quizzes also help the students focus on relevant aspects of the lecture's contents. Quizzes for self study help them get a deeper understanding of the content and evaluate their own learning, for instance by realising aspects they have misunderstood. They provide also a *to do list* for students that require clear instructions on how to achieve the learning outcomes (that is, the non-independent students).
- For problem (v): Quizzes during the lectures provide direct feedback about the student engagement and understanding of concepts in real time. Quizzes for self study provide feedback about how much the students work on the subject, the level of understanding of the content of the course, and when they work on the course, e.g. do they work equally distributed along the block or mainly the week before the exam?.
- For problem (i): Motivation and achievement go hand on hand (Rea 2006, Robinson 1996). Motivation and engagement is positively influenced by activation during the lectures, the level of understanding and the confidence in one own's achievements (Rea 2006). Therefore, I considered quizzes to be also relevant for addressing problem (i). Additionally, I believe also that the format of quizzes for self study is appealing to the students that do not feel like putting aside e.g. two hours to learn math. The hidden hope is that the students start doing a quiz thinking it will take 10 minutes, but they get trapped with some question they do

not understand, and that this leads to them spending time reading the lecture notes and trying to understand some aspect of the course.

In what follows I describe how the introduction of quizzes was performed and evaluates how it might have affected their learning outcomes.

Implementation

Quizzes during the lectures: clickers

We used the online tool *Socrative* (http://www.socrative.com/) for the quizzes during the lectures. With this tool, the students can answer a multiple-choice question using internet connection from the phone, tablet or computer. I gave them 3-4 questions in each 2-hour lecture.

An example of one of the questions posed to them when learning about complex numbers is the following:

Question: Solve the following equation

$$x^2 - 4x + 5 = 0$$

The students were given some minutes to solve the equation. During this time I walked around the auditorium and answered questions, helping with problem (v). Afterwards, they answered online the following multiple-choice question (two of the options are correct):

Question: Which of the following is a solution to the equation $x^2 - 4x + 5 = 0$?

(a) $2 - i$
(b) $2 - 4i$
(c) $2 + i$
(d) I couldn't solve the exercise.

I could follow in real time how many of them had answered and what they had answered. The amount of time I spend in clarifying the answer and the given details were adjusted to the outcome. The practical aspects worked surprisingly fine and Socrative could handle the about 100 students that would answer the questions.

The tool by itself does not help addressing problems (i)-(v) above, other than introducing variation during the lecture. The tricky part is to choose the right questions and think carefully about the questions being asked.

Taking into consideration the recommendations in (Mathiasen 2011) on the choice of questions, I tested out questions of the following type:

- Application of a result
- Repetition
- Short calculations
- Interpretation of graphical objects (important for biologists)
- Intuition inviting
- Discussion inviting.

The choice of questions was adjusted as the course progressed. For example, I thought it would be a good idea to introduce small bits of “inductive” learning. To this end I gave them questions that showed some situations and examples and asked them to figure out a rule. However, the students got very confused and unmotivated with this type of questions and I dropped them later on.

As the course evolved I moved towards questions based on repetition of the topic being covered and involving short calculations. That is, I would introduce some result, exemplify it with some exercises, and then ask them to solve a small exercise. This seemed to work fine and most of them were actively working on the exercises during the lectures.

Socrative provided not only a tool for the students to follow the lecture, but also gave me a clear picture of what was going on in the room. A typical day would start with most of them answering the questions, but by the end of the lecture only half of them were answering. I suppose they were getting lost and stopped listening, but this is definitely an aspect one has to address and avoid. One possibility why this happened is that I planned the lectures such that knowledge was being build as the class developed. Although this is a typical approach in mathematics, it means that when a student gets lost, there is no way back in. Therefore I think that next time I teach the course I should plan the lectures with “catching points”, such that the students that get lost in one step, can get back in after a short while.

Quizzes for self study

There were a total of 9 optional online quizzes and 1 obligatory quiz (although it was not obligatory to pass it). To motivate them to take the quizzes and to align the learning tasks with the assessment of the course, they were told that half of the exam would be multiple-choice based, with questions similar to those in the quizzes.

After taking the quiz, the student would only know whether his/her answer was correct, but in case the given answer was not correct, the correct answer was not given to the student. However, the students were allowed to take the quiz as many times as they wanted. The goal with this strategy was to give the students time to think why their answer was wrong.

I suggested them to take the quiz right after the lecture to assess the learning outcome of the lecture, and then again after having studied the material and done the corresponding exercises. A very small group of students followed this suggestion.

I combined easy questions based on repetition with questions that required a deeper understanding of the topic. I also added a few questions addressing typical misunderstandings.

The overall participation in the online quizzes was not as high as I would have wished. As of July 2015, the participation in each quiz is the following:

Quiz 1. Geometrisk vækst	144/222 Fuldført
Quiz 2. Lineære diskrete modeller i én variabel (del 1)	116/222 Fuldført
Quiz 3. Lineære diskrete modeller i én variabel (del 2)	103/222 Fuldført
Quiz 4. Lineære diskrete modeller i to variable (del 1)	96/222 Fuldført
Quiz 5. Matematiske værktøjer (del 1)	96/222 Fuldført
Quiz 6. Matematiske værktøjer (del 2)	82/222 Fuldført
Quiz 7: Lineære diskrete modeller i to variable (del 2)	72/222 Fuldført
Quiz 8: Diskrete modeller i en variabel	75/222 Fuldført
Quiz 9: Diskrete modeller i to variable	70/222 Fuldført

Fig. 30.1. The overall participation in the online quizzes.

Evaluation

Evaluation of the effect of the quizzes in the students learning and in particular in handling problems (i)-(v) is performed based on the following points:

- The students' comments in the course evaluation survey (45% of students answered the survey).

- The final grade.
- Focus-group meetings: three times during the block a group of student representatives meets with the teachers of all the subjects in the block and discusses the progression of the course. A summary for each meeting is produced.

The self-reported time devoted to the course increased, with the percentage of students working between 15 and 25 hours per week on the course raising from 43% to 61%.

Although the student's evaluation of the quizzes in the survey is not necessarily correlated with how much they learned, it is still an important measure. For a course in mathematics in the life sciences, I consider it is extremely important the overall satisfaction of the students with the course, because that is the main motivation they have to learn.

Final grade

About 205 students took the final exam in January. The final grades for the combined subject Mathematics/Statistics are distributed as follows (the distribution is not that far from what the students expected):

0:	15,6%
2:	5,9%
4:	20%
7:	28,3%
10:	19%
12:	11,2%

If we consider exclusively the mathematics part, then the pass percent is at about 72%, which is 10 point higher than the year before. Of course the group of students changes every year and comparisons cannot be easily done. One could also argue that maybe the exam was easier, but I do not believe this was the case. On the contrary, the use of multiple-choice questions allowed me to evaluate more aspects of the course in the exam.

The students grade cannot be taken as a direct indicator of the effect of quizzes in the students' learning, because other changes not discussed in the report were also introduced to the course. However, combined with the students comments, it is fair to assume that they contributed positively.

About Socrative

Socrative was generally well received by the students, to the degree that the two subjects they take in parallel to mathematics (*Statistics* and *Population Biology*) are considering to use Socrative from next year on.

The students valued the tool positively because it introduced variation in the lectures, and because it made them think about the content that was being discussed. Here are some specific citations (in danish):

- "Socrative var en rigtig god måde hvorpå man fik mulighed for at sætte sig ind i kurset og tænke over mulige svar - så til næste år, bliv ved med det!"
- "Når man engang imellem i det sene timer har siddet og faldet lidt hen og mistet koncentrationen, kom man da lidt med igen ved at bliver involveret i form af spørgskemaer på Socrative."
- "Brug Socrative, holdt mig vågen og opmærksom!"

For many of them, Socrative meant variation during the lecture and hence it helped them keep concentration, in agreement with the studies on student activation (e.g. (Freeman et al. 2014)).

Some students expressed though that Socrative took too much time during the lectures. The time variable is definitely a critical aspect of the use of clickers during lecturing (Mathiasen 2011). It seems impossible to find the right time, such that all students learn optimally. To me, for large classes, the question is to decide whether there is a gain when looking at the class in average, and not at the individual learning. In my particular case, there seem to be enough evidence that the students valued the use of Socrative.

About quizzes for self study

The students expressed that they liked the questions in the online quizzes because they helped them follow the course. They specially valued the obligatory quiz, which forced them to really take things into matter and work on the subject. The suggestion they gave me was that there should be more obligatory quizzes!

Here are some specific citations (in danish):

- "De ekstra quizzer i matematik har også været rigtig rare, da man føler sig mindre lost, når man har lidt svarmuligheder at gå ud fra. Den obligatoriske opgave var faktisk også en positiv oplevelse! Jeg selv, og andre jeg har snakket med, fik et meget mere afslappet forhold til tanken om en eksamen, efter at have taget testen med gode resultater."

- “Quizzer i matematik var godt, så man fik en fornemmelse af hvor man lå.”
- “Det var super med obligatoriske quizzer (...) Gerne flere af dem, så man bliver tvunget til at få styr på tingene undervejs (og så underviserne let kan se, hvor det halter...)”

Conclusions

Overall I think that the use of quizzes, both during the lectures and for self study, have contributed positively to handle problems (i)-(v) outlined above. They helped in creating a good atmosphere during the lectures and in the course overall, in that the students felt they had enough structured material to work with and that they were guided towards what they should learn.

Changes need to be made in the type of questions being addressed during lectures. One also needs to think about ways such that the faster students do not have the feeling of wasting their time while waiting for the rest of the class to finish the small exercise. The fail of inductive questions was disappointing, but maybe the error was on the specific questions being asked, and not on the fact that they were inductive. I will definitely try to introduce them again, after reconsidering what might have gone wrong.

The survey and the focus-group meetings point at that the students found the type of questions in the quizzes useful, but they did not take them as often as desired because of deadlines with another course. Considering that the average time the students devote on the course is still a bit below expected, the possibility of more obligatory quizzes needs to be considered. This is in principle against the idea that the students need to be responsible for their own learning, but, as discussed above, maybe it is not this subject the place to achieve this.

31

What role can Prezi play in students' learning process?

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Abstract

This project offers an initial evaluation of using the online learning platform Prezi as a tool for increasing student learning within a MA unit in human geography. It does this by comparing the use of Prezi to four other learning activities conducted during the course. The aim of the project is to see whether the use of this technology became an end in itself, thereby distracting students and detracted from their learning, or whether it added some value to the course. Data comes mainly from five semi-structured interviews with participants. The qualitative data suggests that students appreciated Prezi because it allowed them to be more creative, to select and condense knowledge and to offer a new dimension to presenting knowledge. But, overall, lectures, discussion and group presentations were more important than Prezi in terms of their learning process. The only activity which was less important than Prezi was the other addition to the course: formal debates. Prezi appears to be able to complement students' learning when they have been able to acquire knowledge through other teaching activities. In essence, it can enhance learning based on more traditional, tried and tested teaching techniques.

Introduction

Active student participation during university education is seen as an important way of achieving the intended learning outcomes of courses and programmes. The belief is that student participation helps to achieve higher-level learning outcomes (such as hypothesizing, applying and reflecting) compared to passive and surface approaches to teaching (which may only support students to listen, memorize and repeat). Not only does activity itself help memory and recollection, but active participation by students reduces the learning deficit experienced by diffident and less academically-orientated students vis-à-vis their more able and confident counterparts (Biggs & Tang 2011*b*).

This project offers an initial evaluation of using the online learning platform Prezi as a tool for increasing student learning in the classroom. It does this by comparing the use of Prezi to four other learning activities conducted during the course: lectures; formal debates; group presentations; classroom discussion. Through this comparison, the projects aims to highlight what Prezi can and cannot contribute to students' learning process.

The project report is structured in five sections. First, full details of the course are offered along with a description of the author's role in teaching and course development. Second, the rationale for the study, and the problem the study aims to reflect on, is introduced along with the overarching and specific research questions of the study. Third, the methods used to evaluate the teaching activities in the course are explained. Fourth, the results, the reflections of students and interpretation by the author are presented together. Fifth, this leads to a broader discussion and the tentative and necessarily suggestive conclusions of the study in relation to teaching in higher education.

Course description

The course constitutes the first part of a 15 ECTS MA course in geography taken in blocks 1 and 2. Both parts are entitled 'Environment, Society and Development $(1 + 2)$'. The course we are concerned with here is ESD1 which takes place in block 1. It introduces students to a genealogy of theories within development geography from the Second World War: modernisation theory; structuralism; dependency theory (and associated Marxist approaches to underdevelopment); neo-classical economic approaches as well as more recent post-structuralist and post-colonial theories. It also covers topics of central importance to current development research, such as poverty, participation, gender and value-chain approaches. From 2014/15 the course will be separated into two separate 7.5 ECTS courses due, partly, to the difficulties in combining both the developmental and environmental sides in a coherent syllabus and exam. The intended learning outcomes of the course are included in Appendix A.

In 2013/14 the course took the form of 14 sessions which ran through September and October 2013 with an average class taking 150 minutes. Twenty two students participated in the course and completed the exam. The majority were Danish with their first degrees in geography or related disciplines from Copenhagen, Åarhus or Roskilde. They had differing degrees of work experience, some with a number of years of employment at NGOs or government bodies. The majority have travelled abroad, some for a considerable length of time. The international students were two Zambians, three students from the US, one from New Zealand and one from Brazil. There was a considerable mix of abilities in the class, with some older students possessing deep knowledge on development geography and others coming completely fresh to the subject. The challenge was to tailor teaching tools to engage all students and allow those students with more experience to share their knowledge with the rest of the class.

Each class would drill down into the literature on one of the theories or topics in development geography. Students were required to read mandatory texts and were provided with a more extensive set of optional readings for each class (see Appendix B). During the first class, students chose which of six groups they would be part of and these groups remained constant during the course. Each of the 14 sessions was broken down into chunks. For example, the timetable for Class 4 which was on dependency theorists and associated thinkers (see Appendix B for the expected learning outcomes and reading list) was structured as follows:

09:00 Presentation of mandatory articles by Group 2, followed by discussion in plenary
10:00 Lecture on dependency theory and associated schools of thought
11:15 Debate between Group 1 and Group 2 – Modernisation theory vs Dependency theory

The author first taught ESD1 in September 2012 during his first four weeks of employment at the University of Copenhagen. He was obliged to complete the first 7 sessions after which a colleague facilitated the last seven sessions. In 2012 the author was provided with a set of readings, a reading list, a classroom and a group of twelve MA students. There was no course manual. There was also no time for any alterations to the course nor any space for reflections between the teaching classes. It was simply a matter of delivering the material in the format in which he had experience: lectures, student presentations and group discussions.

Due to the opportunity to teach all 14 sessions in ESD1 in 2013/14, the author made some alterations to both the content and structure of the course. In addition to writing a course manual, completing intended learning outcomes for the course and for each class, the author introduced two new activities within the class: formal debates between groups; and the use of Prezi, an on-line working environment where group members can collaborate on a canvas to create a non-linear presentation using most kinds of media. The students were introduced to Prezi in Session 1 and were informed they would use it to offer present their summary of the course in Session 14. They were also informed they would be given a small amount of class time to work on it.

In addition to the three previous activities, this led to five main types of learning activity in the course:

1. Lectures
2. Formal debates
3. Group presentations
4. Discussion
5. Prezi

Rationale and research questions

The rationale for this study was that a preliminary literature review highlighted a very limited number of academic articles which focus on how Prezi can contribute to learning in higher education. Most recent articles, such as Perron & Stearns (2010), Lightle (2011) and Laufer et al. (2011) simply offer an overview of what the software does, not whether students find it contributes to their learning. Whilst bender & Bull (n.d.) and Campbell & Williams-Rossi (2012) focus on students' experience of using Prezi, their studies focus on secondary education. One exception is Conboy et al. (2012) who discuss its use by students at Liverpool John Moores University, UK. Based on focus groups with undergraduate students and interviews with both students and staff, Conboy et al. (2012) found that Prezi encouraged non-linear learning amongst students, encouraging the use of mind maps and brainstorm techniques to a greater extent than Powerpoint did. Moreover, they found that students appreciated the ability to create and edit documents simultaneously through Prezi (although they would have to utilize a separate chat function as this is not integrated into the software). Lastly, they found that Prezi was particularly appreciated by some under-performing students whose learning was more visual than text based.

The dearth of literature in using Prezi as a teaching tool within higher education is also evidenced by searches of key science education and higher education journals. Searches of *Studies in Higher Education, Higher Education Studies, the International Journal of Science Education, Science Education, Studies in Science Education and Cultural Studies of Science Education* did not yield any articles that investigated the use of Prezi in higher education. Whilst there does appear to be a gap in the literature, it is also important that this project focused on a particular problem. The issue it focused on is whether the use of this technology became an end in itself, thereby distracting students and detracted from their learning, or whether it added some value to students' learning process. This was through the comparison to the other, more established, learning activities.

To summarize, the main research question for this study was:

- To what extent and how does Prezi contribute to students' learning process?

Subsidiary questions were:

- How does Prezi compare to other teaching activities?
- What is an appropriate role for Prezi within higher education courses?

Methods

Due to the limited time and budget for this project, the main form of data comes from five semi-structured interviews with participants in ESD1. These typically lasted 30 minutes and had three sections. First, students were asked about their university education and the teaching activities and assessments formats they had been exposed to in other institutions. The aim of this part of the interview was to encourage students to discuss their experiences of tertiary education, to relax and to try and establish some form of rapport with the student. We then focused specifically on the ESD1 course and participants reflected on which of the five activities they found beneficial for their learning. The last part of the interview took the form of a ranking exercise where the students positioned the five activities in order of which contributed the most to the least for their learning process. The interviews were transcribed and coded using Nvivo 10. This interview data has been supplemented with some data from a generic end-of-module questionnaire which included both Likert scales and open-ended questions.

Naturally, to rigorously test the impact of an intervention in a classroom setting in a statistical sense, one needs to control for selection bias. Typical ways of overcoming this problem are to run randomized experiments, or when this is not possible, to use quasi-experimental methods to try and recreate the conditions of a treatment vs. control comparison. It should be apparent from the above that such methods were not feasible within the scope of this project. Instead of offering statistically certainty, a qualitative study like this offers suggestive results. But this does not mean they are anecdotal: they help to highlight key processes and behaviour which often underpin the impact findings that quantitative studies can offer. In this respect, they are a vital first step in understanding how an intervention works and whether it should be scaled-up and evaluated rigorously.

Results and student reflections

The results from the study are divided into seven sections. A quick overview of participants' educational background is offered before we discuss students' experiences of each of the five main types of teaching activity in ESD1, ending with Prezi. We end by presenting the results from the ranking exercise.

Participants' educational background and experience

The students came from a wide range of disciplines stretching from nutrition to wildlife management and to economics. All had experienced tuition within at least one other Danish university and many had studied in a number of cities or countries. The students displayed a variety of experiences of teaching methods in higher education. Most commonly encountered had been lectures and group work. The size of lectures varied from 20 up to 300. Three students were also familiar with tutorials, small reading groups of 10-15 where a tutor goes through the lecture material in more depth and in a more comfortable environment. The students had also experienced a wide variety of group work projects and exercises, which lasted from one day through to a whole semester. Group sizes also varied from 2 through to 50. Only one student referred to fieldwork as an educational activity. One had also experienced timed exercises classes with closed questions to complete.

Lectures

All of the students interviewed felt that including lectures in the course were an important, and for some, vital part of their learning process. As student C stated:

> *"Well... I am typically taught in that way... and I feel that if I didn't have that in the course I would feel that something was lacking. Often in courses here I feel that there are not enough lectures... As a teacher is a teacher and they should know more about the subject than the student...*
>
> *So if you didn't have lectures...?*
>
> *I would feel lost, as the discussions wouldn't be relevant as I wouldn't know if they were... Accurate. It's about accuracy, being able to guide the discussion in an appropriate way. It is also about authority, I suppose"*

But the balance between lectures and other classroom activities was varied for the respondents. For example, student D complained that there were too few lectures in the class. This was echoed by 3 of 16 respondents to the end-of-course evaluation. On the other hand, student E remarked:

> *"The lectures were good to get some of the bullet points out, but then I tend to switch off during the lectures and I will lose valuable learning from the lecture. I would prefer shorter lectures and more classroom discussion."*

Clearly, the right balance between lectures and other teaching activities depends on the nature of the students themselves.

Formal debates

A further teaching activity was a series of formal debates where two groups would prepare and conduct a discussion focused on a proposition. In each debate, each group's position would reflect a key theory of development geography. The respondents appear to have enjoyed and appreciated the debates. As students A, B and C stated:

> *"Basically... debates are very normal and should be encouraged (laughter)... in a society for progress to be there. This was a good way for the students to be active. Students weren't just being active, but they were arguing based on what you have learnt, that makes you to be awake, that was very good"*

> *"Yes, they were useful. It was good that I participated in the debates. It gives confidence in what you are doing, that you have to stand for what you are talking about, be able to find reasons to defend the line of thought. For me I think it is one of those activities that is important because you can dig further in what you are trying to put across. You have varied views and you try and come up with imaginations before you sit there and start and talk...debates may actually make you go further."*

> *"I really liked the debates although I sucked at it myself, but I don't know what happened, but I really think it was funny and difficult and I was so impressed with the guys, you know, that's a way to actually use, your knowledge. Then you have to come up with counter arguments fast, that's a good way to digest what you have read. It was a good idea and it was funny."*

But this feeling wasn't shared by all the interviewees. For example, student E was less enthusiastic:

> *"There were just two groups with few other people pitching in. They were fun to listen to but I don't get much out of them, Typically, I will follow the first 5-6 arguments and then I would lose concentration and drift off. The entire idea of following the debate has gone and you've lost some of the arguments.*
>
> *In the first debate we had group feedback on the debate? Was that helpful?*
>
> *I can't remember that"*

Once again we find the degree to which students appreciated a learning activity depends on the character of the student.

Group presentations

The students also had some mixed views on the use of group presentations in the course. Student E found them to be only helpful to his learning process when he participated, not otherwise:

> *"For me, it was good to do them but not to listen to them. When I was forced to learn I enjoyed it, but then listening to other groups was difficult. Like in the introductory class, I was in group one and realise that I had less than 48 hours to read 70 pages and then present this to the class. In academic English. That's a large hurdle to climb. Sometimes you just have to limit your ambitions, and focus on what is most important to present to the other people in the room."*

Similarly, student C felt that it was only when she was part of the presenting group that she benefited from this kind of classroom activity. Student C also highlighted how the student presentation of readings led, in some cases, to superficial repetition and memorizing instead of deeper-level reflection on how the articles fed into the intended learning outcomes:

> *"I think it's difficult with the presentations as that you mainly read for when you are doing the presentations, the rest of the time you know that someone will present them so you don't prepare. That is what happens. And I think it would have been much better, if the presentations were, because I really like that at the beginning of each class you have the learning outcomes, I really tried the two times I was presenting, but we really didn't succeed at all, but I think it would have been better if you only do one presentation each group, and the presentations should be about the learning outcomes. So I think there were too many group presentations."*

Such a comment is useful feedback as in the future it will be helpful to try and steer group presentations more towards the intended learning outcomes of each class (to try and reduce low-level learning behaviour such as memorizing copying and paraphrasing). Student C also had ambivalent feelings towards the group presentations, but this was mainly due to her personality

> *"I also resented the presentation as well, because I do not like speaking in front of a group so much. But I found them to be a good way of discussing papers in a class because a lot of time my interpretation were different from the other people who had also*

read them and I really enjoyed the discussions in class after the Powerpoints, because they made me see different points of view that I would never have thought of before. I don't even know how those people thought of those things to say, but I was nervous, really nervous. Not that it was horrible, but just that I was really nervous."

Through the anxiety, we can also see how this student found the presentations as a good springboard for the broader discussion in plenary.

Discussion

Surprisingly for the author, all of the students interviewed felt this type of teaching activity was one of the most important for their learning:

> *"The other part was... the open discussion in class, I found this a very positive one, moving away from the experience I have in my country, with the lecturer just talking. In ESD1, it was different, if your mind was not clear you could just raise your hand and ask and then it would be cleared, you would understand more. For me, that made me feel part of parcel of the course. I appreciated it."*
>
> *"I think they are the most interesting part of it. I'm not sure if we can make checks on the learning outcomes afterwards, but it's a good part. There should have been more space for discussions, I think so..."*
>
> *"I like it with a short introduction and then it develops into a classroom debate where everyone is pitching in, you then really get to hear what other people have got out of reading the same text. It can really give you the 'ah-haa' experience, instead of being in a little bubble of your own, you can also expand your horizons and you can also use other people's arguments and use their way of viewing the texts"*
>
> *"It engages all the students, including me… the classroom discussions were most important for me, where everyone pitched in. As far as I read the classroom, that is."*

But this is not to say that all people in the class participated equally. For example, one student was quite reserved about taking part in the discussions:

"I enjoyed listening to them. I enjoyed listening to the discussion, I can't talk and think and listen quickly .. or I would say something I didn't mean...

But you participated as well?

No... (laughter)... I mediated sometimes but I didn't say anything...

You enjoyed them so much but you didn't participate? Why? So often when people say they really enjoyed an activity it was because they participated, but for you... ?

Because I don't think of those things....the things that people were saying were new, knowledge that I didn't connect myself, so sometimes I would have ideas... but I didn't think they were well developed enough to articulate... I guess when people are speaking... I find that Danish people are used to participating in class and voicing their opinions... in my learning system it was more you raise your hand and ask the teacher directly and often you do not contradict them. So this comes from your own educational background...

Did you feel that this course... made you more able to do that?

A bit. But the terminology... such as the economic terminology.. and I am not so well versed in neo-Marxism and orthodox Marxism so.... The terminology was a bit intimidating....I've studied these theories before.... Two times before, but this time they sunk in a bit more."

This now brings us to the main subject of the project, Prezi.

Prezi

To recap, students were introduced to Prezi in the first class and asked to work their group to complete and present a summary of the course in the last class (session 14). Four of the five students found Prezi to be a positive addition to the course. For example, student A stated that:

"At first I was confused and thought... I don't really know about this Prezi thing. But I really enjoyed it afterwards (laughter)... so

it was one of those creative ways of involving students, it shows some high levels of creativity and can bring a new dimension to the course"

Student C offered a similar experience of growing to like and enjoy the use of Prezi:

"At first I resented the Prezis a bit. But when I got to do them I found them to be very helpful. You had to really pick out what you thought was important to remember from the different theories... and the Prezi presentations. You felt a bit nervous about it... But many people in my group told me that it's a good way for them to condense their knowledge in an accessible way."

Two further students stated were more fulsome in their praise of the learning activity. For example, one stated that:

"Maybe the other activity which I will never forget and which I can add to my CV now is learning how to use Prezi. It was wonderful for me. This was an activity I didn't know about so I heard about it in this seminar class, so maybe even for my presentation of my thesis I may try to use the same Prezi to a different forum."

The final student was less enthusiastic about Prezi but this was mainly due to the group dynamics instead of Prezi itself:

"The Prezi presentation became a bit of a nuisance. We had to finish this off. We didn't work on it during the course but pushed it to the end. We then tried to get cracking at it during the vacation week and the end of the course but it turned out the girls were out travelling. One guy was sick during that week. There were only two of us. I would like to use Prezi in the future as it is a more vibrant interactive media to use, instead of a .ppt."

To summarize, students appreciated Prezi because it allowed them to be more creative, to select and condense knowledge and to offer a new dimension to presenting knowledge. We also see students opinions about Prezi through the ranking exercise.

Ranking exercise

The final section of the interview asked students to rank the five classroom activities in terms of how they benefited their own learning process. The

		Ranking of learning activities in ESD 1 20013/14			
Top	Lectures	Discussion	Prezi	Lectures	Discussion
	Group presentations	Group presentations	Group presentations	Prezi	Lectures
	Discussion	Lectures	Discussion	Formal debates	Group presentations
	Formal debates	Formal debates	Formal debates	Discussion	Prezi
Bottom		Prezi		Group presentations	Formal debates
Overarching	Prezi	Essay	Lectures		

Fig. 31.1. Ranking of learning activities in ESD 1

results are shows in Figure 31.1: We can see how, overall, lectures, discussion and group presentations were more important for students than Prezi in terms of their learning process. The only activity which was less important was the other addition to the course: formal debates.

Does this mean that the innovations introduced into the course hindered students' learning? That they shouldn't be included? We can learn more about the reasons for these rankings through the students own justifications. For example, one student refused for position Prezi with the other activities as they felt it had a special status:

> *"I think Prezis need to have a separate category on its own. It summarized all the activities we have had during the course.. All the activities lead to the Prezi presentations. I regard it as standing on its own, it's more creative."*

One other student accorded the same 'overarching' status to the essay, another to the lectures. A further student reflected that:

> *"It's funny that I was so much against Prezi. You asked us to work on Prezi and I really didn't see the point, like I just had to go to work and it was such a pain trying to learn it. But when I was starting to prepare it at home, I made two... it kind of made more sense to me that way."*

We can see in both of these quotes that the use of Prezi as a summarizing tool does have some value. Without wanting to read too much into quotes, it appears to have allowed students freedom to choose the way they wanted to review and condense the material. It is perhaps this freedom to use whatever media you like, in whatever sequence and structure you like, that students find most engaging. What is also clear from this study is that Prezi appears to complement the more established and tested teaching activities. It does not appear to detract from the learning process and allows students leeway and a blank canvas on which to depict their understanding of the theories at hand.

Broader discussion and conclusion

Conboy et al. (2012) found that Prezi encouraged non-linear learning amongst students, encouraged simultaneous conduction and editing or projects, and especially supported the learning of students who were more visual in their learning that based. The tentative findings here are that Prezi is not a panacea for student engagement and learning, but neither does it deflect attention from the topics being taught. It was welcomed by students who, despite initial reticence, warmed to the software and found it allowed them to be more creative, to condense knowledge better, and to offer a new dimension to presenting knowledge. The more important finding, though, is that Prezi can only be used by students when they have been able to acquire knowledge through other teaching activities. It appears to be able to play a role in teaching in higher education when put in the hands of those who will learn it fastest: the students. But it's a limited role which will enhance learning based on more traditional, tried and tested teaching techniques.

As we saw earlier, the use of technology in the classroom can, in some cases, become an end in itself, thus distracting students from their learning. This tentative investigation in the use of Prezi as a tool for students to summarize a 7.5 ECTS course found that it appears to complement existing teaching methods well. Students appear to enjoy the freedom and creativity the software affords them. But there is no evidence presented here that suggests Prezi should be seen as anything other than one teaching activity amongst many within a broad, varied and, of course, highly participatory teaching regime.

A Appendix 1

Intended Learning Outcomes

Knowledge: Students will be able to...

- Identify, locate and summarise the broad theoretical underpinnings of research within development geography and relate this to debates and shifts in the wider social sciences;
- Describe how theories of development geography have changed in the past six decades and be able to see the relationships and ruptures within this time period as well as connections to earlier theories of development;
- Identify a particular theoretical tradition or topic they have interest in.

Skills: Students will be able to...

- Succinctly summarise and present, both verbally and in writing, material based on individual and group work;
- Collaborate with fellow students in compiling an overview of theories of development geography and contribute to the presentation of this overview to the class;
- Conduct a literature review to select two recent articles from geographical journals to be discussed in their essay;
- Structure and write a 2,500 word essay.

Competences: Students will be able to...

- Compare and evaluate different traditions in development geography and apply this knowledge to assess the appropriateness of these schools of thought for answering different types of research question.

B Appendix 2

Class 4 - Thursday 12th September - Dependency theorists and associated thinkers

By the end of this session students should be able to: describe and differentiate between different schools of thought within Marxist-inspired theories of dependency and development; recognise the particular sets of political and economic conditions which fostered this set of theories; and highlight the weaknesses of these approaches to development geography.

Mandatory reading

So, A.Y. (1990) Social Change and Development: Modernisation, Dependency and World-System Theories, Sage, London. Chaps. 5 and 8.

Amin (pp. 20-25) in Simon, D. (ed.) (2006) Fifty Key Thinkers on Development, Taylor & Francis, US.

Cardoso (pp. 61-67) in Simon, D. (ed.) (2006) Fifty Key Thinkers on Development, Taylor & Francis, US.

Frank (pp. 90-96) in Simon, D. (ed.) (2006) Fifty Key Thinkers on Development, Taylor & Francis, US.

Optional reading

Wallerstein, I. (2004) World Systems Analysis, Duke University Press, London, Chps. 1 and 2.

Wallerstein, I. (1983) 'The Rise and Future Demise of the World Capitalist System: Concepts for Comparative Change' in Alavi,H. and Shanin,T. (eds) (1983) Introduction to the Sociology of 'Developing Societies', Macmillan, London, p29 - 53.

Brenner, R. (1983) 'The Origins of Capitalist Development: A critique of 'Neo-Smithian' Marxism' in Alavi,H. and Shanin,T. (eds) (1983) Introduction to the Sociology of 'Developing Societies', Macmillan, London, p. 54 - 71.

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