This is the first 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.

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Improving University Science Teaching and Learning – Pedagogical Projects 2008, vol. 1

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Improving University Science Teaching and Learning

Pedagogical Projects 2008

Volume 1

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Improving University Science Teaching and Learning

Pedagogical Projects 2008

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Preface

Jens Dolin

Head of Department of Science Education, SCIENCE, University of Copenhagen

It is a great pleasure for me to introduce this collection of pedagogical projects originating from a teacher training programme at the University of Copenhagen.

The faculties of Science (SCIENCE) and Pharmaceutical sciences (FARMA) have had a formal cooperation about a joint teacher development programme (TDP) for associate professors and post-docs since 2003. As of 2008 the faculty of Life Sciences (LIFE) has joined the programme, so the TDP now addresses the three science oriented faculties at the University of Copenhagen. The programme is run by the Department of Science Education, SCIENCE, and it is currently the most extensive programme at the University of Copenhagen both in terms of number of enrolled participants and in terms of the workload for the participants.

The founding idea of the course is to give the participants some research based tools to reflect on their own teaching. This book is a way of showing some of the results of these reflections. But a more profound impact of the course is undoubtedly its contribution to develop the participants' everyday teaching practice – and in a wider perspective to enhance higher education at the university.

It is the hope for us, that the wide-ranging contributions will inform and inspire other teachers within higher education to consider and to develop their own teaching.

Introduction

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Introduction

The pedagogical development projects presented in this anthology – the first in a series – have been made as a part of the teacher development programme for three faculties at the University of Copenhagen. The programme has a practical part, where participants' actual teaching is supervised by senior teachers, and a theoretical part where participants are introduced to fundamental pedagogical principles of relevance to university science teaching and learning. In the theoretical part, participants also make two projects: One related to student learning, and one that is specifically aimed at developing their own teaching. This volume contains these final projects for the the group of participants in the TDP in 2008/2009. For further description and information about of the TDP, see (Christiansen et al.; 2009).

The course was given in English, but many participants have chosen to write their final projects in Danish. As a result, the current volume have contributions in both English and Danish.

The contributions in the series are not scientific papers as such, although several contributions do have potential to become that. Instead, they are personal accounts of how and why teaching has been developed in various ways. As such, the contributions tell us how teachers actually work in developing their courses, and show us what they learn in the process. In this sense the papers show us something that scientific papers often fail to show. Many of the contributions analyse teaching where something went wrong and consider the lessons to be drawn from those situations. Good teachers see such situations as opportunities for improving their practice, but only rarely do such accounts find their way to the peer-reviewed educational journals. Likewise, many of the problems described in the contributions are problems that are relatively specific to the teaching institution at hand, and this specificity is also something which is ordinarily downplayed or even erased in publications addressed to a more general audience. Here, we have the unpolished situations described in their specific ugliness and beauty, and see the teachers' attempts at bringing general considerations to bear on them. Most of the contributions show that this endeavour is relatively successful. In this way, what the contributions may lack in scientific rigour, they have in *authenticity* – and honesty. In this sense the contributions in this series can be seen as complementary to standard scientific papers, rather than mimicking them. In improving university science teaching and learning, we may learn a lot from studying the personal development projects in this volume (and series).

The types of problems dealt with in the development projects are very diverse, but the approaches to dealing with the problems show a common approach: Focussing on student outcomes rather than presenting content. In this respect it is clear that the teaching material used in the course, particularly John Biggs and Catherine Tangs description of "constructive alignment" (Biggs and Tang; 2007), has been an important source of inspiration for many of the participants. We have chosen to divide the volume into four different parts – (1) planning new courses, (2) evaluating and revising existing courses, (3) planning courses with many involved teachers, and (4) developing interactive learning environments. The individual contributions will be introduced below.

1 Planning new courses

The first contribtion in this part is by Jacob Wienecke. Jacob describes his own design of a completely new course on neurobiological perspectives on learning. Jacob provides a course plan and very detailed and well argued analysis of the structure and content of the weekly exercises, which will vary from students planning a learning process for children learning ball-play, to lab exercises with analysis of a brain. Jacob also provide a discussion of how e-learning assignments will provide support for student learning out of class.

The two subsequent projects by Lasse K. Bak and Peter Naur both concern the planning and execution of (two different) one-day ph.d. courses in relation to the PhD ULLA summer school held at the Faculty of the Pharmaceutical Sciences in summer 2008. The course developed by Lasse K. Bak and colleagues was on glial cells. It is the first time the course was given, and the project includes a justified description of the design and an analysis of the outcome for the students. In the description of the considerations behind the developed intended learning outcomes for the course, particular consideration is given to the students' varied professional backgrounds. In addition, Lasse describes the planning and execution of his own lecture in the course, where Brousseau's Theory of Didactical Situations (Winsløw; 2007) was used as the general didactical framework. The lecture included a relatively large *adidactical* element where students had to work and discuss among themselves, and according to Lasse this worked very well. The general course evaluation shows that the students were generally very content with the course as such.

The course developed by Peter Naur and colleagues is about three-dimensional protein structures in drug research, and the contribution contains his analysis and justifications for the design of the course. Peter describes how he has defined some detailed and operational intended learning outcomes and let them guide the design of the program, according to his condensed version of the principle of course alignment (Biggs and Tang; 2007): the most efficient learning takes place when you are doing what you should learn. Using this rule, the teaching and learning activities are in almost one-to-one correspondence with the intended learning outcomes, thus ensuring course alignment. His reflections are based on observations in class and student evaluation which indicate that student found the design very successful.

The theme of course alignment is also clear in Kasper Thorup's contribution in which a new specialized course in Ornithology is suggested for the Master's Programme in Biology. Kasper has assessed the need for such a course by asking students and considering the enrolment for similar courses elsewhere in Denmark. He argues for constructing the course in such a way that it will help fill some of the apparent gaps in the Biology Programme in terms of offering courses that provide students with general capabilities for independent work as required for the writing of the Master's thesis. Specifically he suggests that students' capabilities for reading and assessing scientific papers and working independently towards article production should be central elements in the teaching and learning activities. Moreover, exercises should train students in “real” scientific methodology. Of particular interest in Kasper’s project is his analysis of the general capabilities provided by the Biology programme as such and the possible discrepancy to the capabilities suggested in the stated intended learning outcome of the programme. This, in turn, provides a further justification for the planned course.

Bjarne Styrishave’s and Michael Skovbo Windahl’s contributions both describe new courses that have been developed as a collaboration between teachers at several faculties/institutions, and might as such also have been placed in the third part of this volume. Bjarne Styrishave’s contribution is about the planning and execution of a new course at the new elite education in Environmental Chemistry and Health, specifically the course in Toxicology and Ecotoxicology. The course was planned to be assessed with a multiple choice exam, and Bjarne considers how this form of assessment rhymes with the concept of “elite programme”. If we want students to adopt deep learning strategies it is necessary to use forms of assessment that encourage such learning, and the multiple choice format is therefore supplemented by a “conference” where students present posters of their work. In addition, Bjarne discusses the pros and cons of two different types of evaluation of teaching used in the course; a traditional questionnaire on the one hand, and the so-called Delta-evaluation where students themselves formulate comments, points of criticism etc. on the other. He argues that the two types of evaluation supplement each other and both should be maintained.

Michael Skovbo Windahl’s contribution concerns the development of a new course in “The chemistry of metal ions in biological systems” as a collaboration between the faculties of LIFE, FARMA and SCIENCE at KU. Devising such a course is a challenging task, both in terms of “aligning” interests and goals between the involved teachers, and because of the special considerations on students’ background that are necessary. The main part of the project concerns the development of the intended learning outcomes and considerations on the accompanying teaching and learning activities. Michael describes how the knowledge, skills and competencies aimed at have been described, which complies finely with the policies at the faculty of LIFE and the national framework for description of learning outcomes (“kvalifikationsrammen”). The SOLO-taxonomy (Biggs and Tang; 2007) is used in order to interpret the framework. As for the description of the teaching and learning activities in the course, Michael comments upon different teaching and learning activities to be used in the course, for instance how lectures can be organised so that they allow for independent student work and problem based learning. As such, the project may and is intended to serve also as a set of general guidelines for the many teachers involved in the course, not unlike the endeavour described in the contribution by Katrine Worsaae. Both Michael and Bjarne's contributions analyze many of the difficulties facing any teacher who has to organize a course involving teachers from several institutions, and the projects provide many good examples of how this can be done rationally by open and pedagogically inclined teachers.

2 Evaluating and revising existing courses

Daniel Hofius describes how he has made a substantial, original and well-conceived change of the design of a lab exercise in a bachelor's course on plant molecular biology. The new design introduces an authentic research problem that students have to work on, with the aid of a lab protocol, which they need to refine as the experiment goes along, and interactive lectures to initiate and conclude lab days. Also results are to be handed in, in the form of a scientific lab report to be used by the departments' researchers. Results show that students appreciate the increased learning outcome from the new format, even if students do not fully realize the new report requirements. Students find that Daniel's interactive lecture on more general concepts in the course is in good coherence with the content of the new lab.

Lill Andersen's project describes the revision of a course in economic growth and development at the Faculty of Life Sciences. Lill has given the course once before and experienced that the learning objectives (ILO) were not very well aligned with the teaching and learning activities (TLA) and the mode of assessment. Lill's project describes an ambitious plan to reorganize the course so focus on student active learning is strengthened, and a constructive alignment is obtained. The plan outlined by Lill draws upon Eric Mazur's ideas of peer instruction, and the so-called "theme-assignments" developed by Niels Grønbæk – a format which is very well suited for teaching in the block-structure in use at the University of Copenhagen (see Nils Nybergs contribution for a description of the structure). The latter format will enable students to focus more on the functional knowledge and the higher order cognitive processes. The project includes a very good sample theme assignment.

Nils Nybergs project is also concerned with the possibilities afforded by the block structure for devising new teaching activities, and suggests a redesign of a course in advanced spectroscopy. Nils convincingly analyzes the course in terms of identifying the core elements to be transferred to the new model. Furthermore, Nils has interviewed three students who have participated in the course and used what they learned in their further career. The students' opinions are used to inform the design by checking and contrasting his ideas.

Jack Egelund analyzes a unit in a course in cell biology which covers plant biology. Jack has taught the exercise classes and uses student evaluations and exam results as a basis for his analysis. His analysis is thorough and argued in light of relevant literature. Results show that although students are doing well in the exam and in general like the lectures, a good deal of surface learning may be going on, since the exam format is solely multiple-choice questions.

Nana Quistgaard has analyzed two focus group interviews with students who have passed two slightly different versions of a course in science communication, in which Nana has taught a theme on science centers and museums. Results show that the outcome of the course is not related to the students' disciplinary background, and that students almost unanimously prefer to work in interdisciplinary groups and appreciate the learning experiences the inhomogeneous background provide. The data also gives a valuable insight into students' difficulties in appreciating and applying the course literature, and in engaging in some of the plenary activities. Nana provides three suggestions for utilizing students' multidisciplinary backgrounds in an even better way.

The project by Maria Unni Rømer concerns the General Pathology course for second year students at the veterinary study programme at the Faculty of Life Sciences. The project is about the students' learning strategies, and how to devise teaching and learning activities that encourages more deep learning strategies. The analysis is based on student evaluations, an interesting analysis of the exam set and a focus group interview with a group of students well after the final examination. In spite of fine student evaluations, the additional analysis convinces Maria Unni that a large group of student adopt surface approaches to learning, i.e. focus on memorizing enough to pass the exam rather than developing a real understanding of mechanisms and terminology. Rather than accepting a status quo where surface learning may be a reasonable strategy for students, Maria Unni considers how to improve the situation and develops a template for a new type of patobiological exercises to be used in the course. Maria Unni argues that this exercise template will provide students with opportunity to train their skills at clinical description and consider the mechanisms underlying the symptoms at one and the same time.

3 Planning courses with many involved teachers

One of the characteristic features of the teaching at the three faculties is at many of the courses (particularly in the pharmaceutical and life sciences) involve a large number of teachers – either because of the number of students or because of the degree of specialization in the courses. This situation means that ensuring a common understanding of goals and intentions becomes pivotal.

Ole K. Hansen reflects on his teaching in two partly overlapping courses on genetics - two lectures and a lab. Ole justifies how he has planned the lectures under these quite difficult circumstances. The taught subject was somewhat peripheral to the courses, and students lacked prerequisites. As for the lab, Ole makes a rather thorough re-design and succeeds in designing an exercise which is more motivating and rewarding for the students. The design takes into account that there should be meaningful teaching and learning activities for students when they wait for lab results.

In Victoria Fuller's project we have an analysis of the existing intended learning outcomes of a course in heterologous expression in which she teaches a unit. The analysis informs the specific learning outcomes for her unit, so she will be able to plan suitable teaching and learning activities for the students. She makes a convincing suggestion for improving the intended learning outcomes of the course and argues how she has planned her unit in order to seek to ensure alignment in the course. Victoria also points to the challenge of securing common understanding of the ILO's for the many different teachers involved in the course.

Katrine Worsaae's contribution suggests the use of a so-called competence-matrix to facilitate such common understanding between teachers, and describes how this new tool has been used fruitfully in relation to a field course in marine faunistics. The competence-matrix is a mapping of competences unto content and a consideration of the level based on the SOLO-taxonomy. No doubt this tool can help facilitate a common understanding between teachers, but may also be used by individual teachers planning a new courses.

4 Developing interactive learning environments

Peter Karlskov-Mortensen's project concerns the reorganization of a part of the master's course in biomedicine for veterinary students. More specifically, Peter describes the redesign of the lecture introducing the theoretical background for the polymerase chain reaction (PCR) – a method which is used in the laboratory exercises in the course. Peter makes an analysis of the problems in the course and argues that a fundamental problem for the course is the large curriculum, and the attempts to address this problem have focused mainly on what the teachers should do, rather than on engaging students. Peter proceeds to outline a new organization of the teaching related to the PCR technique, where students are to engage in problem solving activities in groups using higher-order cognitive skills. The lecture proceeds according to the plan, with engaged students. After two to four weeks the students' learning was assessed in relation to the laboratory exercises, where students had to use the PCR method. Although the findings are ambiguous, the majority of students did well and according to the laboratory technician they did better than previous years. Peter concludes by urging that similar changes should be made to other parts of the curriculum. Peter's project is an analysis of problems that are all too common in higher education science (subject matter abundance), and provides an example of how student-focussed teaching may help overcome this problem.

In her project, Stefania Xella reports on and analyzes the results of her new design of a graduate course in experimental and nuclear particle physics. Stefania has developed a problem based learning model, where each 3-hour teaching session (termed "lecture") is initiated or sparked by a problem which is at that point of time beyond the reach of the student, but which guides the interactive lectures alternating with longer problem-solving sessions in small groups, in a way which allows the students to solve the initiate problem by the end of class. Stefania's own analysis of her experience in conjunction with the students' evaluation and exam results, support the conclusion that the model works: Students have a high quality learning experience.

David Gloriam reflects on his teaching in three different teaching situations which are all part of programs in pharmaceutical sciences. An important focus of analysis is the student perspective, especially the different expectations and approaches taken by intrinsically and extrinsically motivated students. David has some very convincing and detailed reflections on his role as facilitator and supervisor, and some well justified plans for further developing his lectures.

Nanna Bjarnholt discusses how students may be motivated for content which is bordering on the students' interests or which is conceived of by the students as having only instrumental value. This problem is a fundamental problem in university science education. Nanna describes how this situation has been the case in relation to her teaching in the subject metabolic profiling – a part of a more general course on plant genomics. Nanna describes how experiences and evaluations from last year's teaching have informed her planning process and led to a drastic reduction of the "lecturing time" and introduction of interactive elements in the lectures, and a strengthening of interactive elements in general – importantly the integration of computer exercises into the lab exercise.

In Vera Kuzina Poulsen's project "Generation of appropriate learning activities for a student-activating learning", Vera describes two different teaching situations in two different courses. Both were interactive lectures in relatively small groups. One was very successful, while the other one was less successful. This is in spite of the fact that the same teaching methods were used in the two situations. By carefully analyzing the two situations, Vera illustrates that no teaching method is universally good and methods that have been found to work in one setting may not work in a different one. Thus, teachers have to adapt and adjust their methods to the specific students involved in order to make successful teaching. This requires a variety of methods to use, and Vera describes a number of good methods that might have been used in the last situation. Vera's story of the two situations highlights a crucially important point for all teaching. Vera's project shows her ability to reflect upon the success of her own teaching, and her will and genuine interest in engaging students by creating stimulating and appropriate learning environments for them.

Finally, Olga Østrup's project concerns the communication between student and teacher in relation to a sophomore cell biology course for veterinary students. Originally the project intended to examine student learning in relation to practicals, but the initial findings led Olga to consider more closely the communication between teachers and students in the course. Specifically, Olga examined the perceived self-efficacy of teachers and students in the course, using a modified version of the STEBI self-efficacy test. Interestingly, Olga finds that students have significantly lower efficacy beliefs than teachers, and uses this finding to explain the perceived reluctancy among students to ask questions. Olga argues, that while the beliefs will most likely change as the students experience success in the study program, students' low self-efficacy beliefs are important to consider in relation to the introductory courses. Olga argues that self-efficacy beliefs are indeed something to take into consideration in university teaching. This project is the first in our TDP course to consider the self-efficacy beliefs of students and teachers, and we hope that the line of thought developed by Olga in this project will be developed further in future projects by other participants.

Part I

Planning New Courses

1

Optimering af indlæringen – et nyt kursus samt refleksioner i forhold til kursets struktur

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Indledning

I mit projekt har jeg valgt at beskrive et nyt kursus, hvor jeg vil drage nytte af det stof, jeg har lært, og de refleksioner jeg har gjort i løbet af adjunktpædagogikumforløbet. Kurset omhandler indlæring ud fra et neuro-biologisk perspektiv, dvs. arbejde med forbedring af indlæringen ud fra det kendskab, man i dag har til hjernen og dens funktion. Man kunne vælge andre vinkler som fx den pædagogiske eller psykologiske, men det er i forvejen repræsenteret på idrætsuddannelsen; jeg vælger i stedet at komme med et nyt bidrag. Samtidig ligger det kursus, jeg beskriver, tæt op ad mit eget forskningsfelt, hvilket vil fremme den forskningsbaserede undervisning, som er et krav til universitetets undervisere.

En vigtig begrundelse for mit valg af projekt er, at jeg er blevet opfordret til at beskrive et lignende kursus som led i en fornyelse og udvikling af idrætsuddannelsen. Undervejs i udviklingsarbejdet har jeg haft mulighed for at diskutere kursets form og struktur med kollegaer, således at det er blevet gennemarbejdet og ikke kun afspejler min holdning til, hvordan kurset kunne struktureres.

Kursustitel

Optimering af indlæring

Formål og beskrivelse

Kursets formål er at sætte fokus på indlæring ud fra et kombineret praktisk og teoretisk perspektiv. Primært er det motorisk indlæring, der vil blive fokuseret på, men der vil også indgå aspekter af ren kognitiv indlæring. Undervisningen begynder med en praktisk indgang til motor learning efterfulgt af en neuro-anatomi-øvelse. Herefter (dvs. i 2. uge og frem) vil undervisningen fokusere på koblingen imellem indlæring (primært motorisk indlæring) og neuro-biologien. Neuro-biologien dækker over fysiologiske og molekylære processer, som er udgangspunkt for, hvordan der arbejdes med indlæring.

Litteraturen til kurset vil primært være publicerede artikler og nogle kapitler fra lærebøger. Sammen med forelæsningerne skal litteraturen skabe det teoretiske grundlag for øvelserne og forsøgene. Øvelserne skal højne forståelsesniveauet samt afkræfte og bekræfte hypoteser om indlæringen.

Praktisk information for selve kurset

Kurset afvikles over 7 uger, hvor der i hver uge er en dobbelt teorilektion på én dag og en efterfølgende dag i samme uge vil der være en hel dag afsat til øvelser og forsøg. De studerende afvikler og deltager selv i øvelserne/forsøgene med hjælp fra øvelsesvejlederen. Undervisningen vil være opdelt i temablokke, og hver blok afsluttes med en e-test, som skal bestås. Til al undervisning skal den studerende medbringe bærbar computer, og den skal være sat op til EDUROAM før kursets første gang.

E-testen er elektronisk og foregår på Absalon. Hver temablok skal bestås, før man kan gå til eksamen. Eksamen er en tredages skriftlig opgave med intern censur.

Målbeskrivelse

Efter kurset skal den studerende kunne:

- basale principper for optimal indlæring ud fra en (praktisk) motor learning-kontekst.
- vælge relevante strategier for indlæring ud fra en neuro-biologisk kontekst.

- det grundlæggende inden for neuro-anatomien.
- beskrive og diskutere IQ-begrebet (i matematisk-logisk, spatial og motorisk kontekst).
- begrunde valg af indlæringsstrategi - herunder optimering af indlæringen samt seriel og randomiseret indlæring.
- begrunde valg af indlæringsformer – herunder simpel indlæring, adaptation og færdigheder.
- Diskutere betydningen af sensorisk feedback og motorisk feedback.
- Sammenligne og diskutere resultater fra dyreforsøg og humanforsøg for at forbedre optimeringen af indlæringen hos mennesker.

Kriteriebeskrivelse for karakteren 12

Den studerende skal demonstrere et grundlæggende kendskab til neuroanatomien samt kunne beskrive, hvorledes de forskellige områder i hjernen bidrager til de forskellige typer af processer, der foregår under indlæring og hukommelse. Endvidere skal den studerende (på baggrund af dyreforsøgsresultater) kunne analysere og fortolke molekylære/cellulære/fysiologiske processer for dermed at kunne udvælge strategier og drage konklusioner for, hvordan man for eksempel kan sammensætte et træningsforløb af en udvalgt bevægelse, hvor indlæringen er optimal.

Refleksioner i forhold til udformningen af kurset

Kursets udformning bygger på flere elementer, som jeg synes er vigtige for at følge udviklingen af moderne undervisning, men også på nogle principper for hvordan et fagligt stof læres bedst muligt.

For det første har jeg reduceret forelæsningstimerne, dvs. der vil kun være én dobbeltforelæsning pr. uge, hvor det vigtigste og mest relevante fagstof præsenteres og diskuteres. Egentligt er det min hensigt, at forelæsningen skal være mere interaktiv end monolog. Énvejs-kommunikation kan være spændende og godt, men risikoen er, at det kan blive kedeligt, og at den studerende mister opmærksomheden og det faglige indhold går tabt. Biggs og Tang (2007) beskriver i relation til forelæsninger med mange deltagere princippet om "aktivitet" for hver 15 minutter (Biggs and Tang; 2007, se figur 7.1 s. 107-110). Princippet bygger på Donald Blighs studier

1. uge	**2.uge**	**3.uge**	**4.uge**
Forelæsning: * Introduktion * Motor Learning * Neuroanatomi	Forelæsning: Intelligens og hukommelse	Forelæsning: Læringsstrategier	Forelæsning: Indlæringsformer
Øvelse: * 9-12: Praktik i hallen - Motor Learning * 13-16: Neuroanatomi	Øvelse: * 9-16: Testning af intelligens og hukommelse	Øvelse: * 9-16: Afprøvning af forskellige læringsstrategier i hallen og laboratoriet	Øvelse: * 9-16: Indlæring og adaptation på cellulær og molekylært niveau i laboratoriet (dyreforsøg)
e-test i neuroanatomi på Absalon	***e-test i intelligens og hukommelses-begreber på Absalon***	***e-test og afrapportering i læringsstrategier på Absalon***	
5.uge	**6.uge**	**7.uge**	**8.-9.uge**
Forelæsning: Indlæringsformer	Forelæsning: Indlæringsformer	Forelæsning: Sensorisk versus motorisk indlæring	***Eksamen:*** ***En tre-dages skriftlig opgave.***
Øvelse: * 9-16: Simpel indlæring og adaptation i hallen og laboratoriet	Øvelse: * 9-16: Adaptation og færdigheder i hallen og laboratoriet	Øvelse: * 9-16: Øvelse i sensorisk og motorisk indlæring på Hvidovre Hospital	
	e-test i indlæringsformer på Absalon		***Opgaven stilles via Absalon og den afleveres på Absalon***

Figur 1.1. Kursusplan

fra 1972 og er et meget godt princip, som jeg kan tilslutte mig, da det bevarer opmærksomheden og øger hukommelsestiden især for “Robert” (jf. “Susan & Robert-stereotyperne” (Biggs and Tang; 2007, s. 1ff)).

Strukturen i dette kursus passer på de ugentlige skemablokke A og C, som beskrevet i Didaktips 5 af Horst and Winsløw (2004).

Øvelserne

Øvelserne er et af kardinalelementerne. Jeg mener, at den optimale indlæring foregår ved at arbejde med stoffet både teoretisk og praktisk. Øvelser skal afprøve det teoretiske stof og andre gange udfordre teoristoffet. Sidst men ikke mindst forestiller jeg mig, at de studerende skal være med til at afprøve selvformulerede hypoteser. En kombination af disse tre elementer over de 7 undervisningsuger vil sandsynligvis højne motivationen hos den studerende, da de selv er med til at skabe deres egen læring inden for det givne pensum.

Beskrivelse af første øvelse (1. uge)

Første øvelse foregår i hallen og omhandler motor learning. I motor learning arbejder man med principper for indlæring ud fra en mere praktisk synsvinkel, som for eksempel: Hvis man i volleyball som makker-par skal udføre sekvensen modtagning, hævning og smash, er spiller A både modtager og “smash’er” (dvs. angrebsspiller) og spiller B er hæveren. Hele sekvensen for spiller A er i virkeligheden meget kompliceret. Den indeholder teknik ift. bold (dvs. baggerslag og smash), placering (før, under og efter boldberøringen), ben-arbejdet samt at spiller B (som er en del af hele sekvensen) har et vist niveau til at kunne placere og time hævningen, således at udførelsen af sekvensen får flow og bliver succesfuld. Under motor learning-øvelsen skal den studerende være med til at analysere og konkretisere problemer, som man støder på under indlæring af sekvenser og bevægelser af denne type.

Første øvelses anden del er helt forskellig fra motor learning-delen, da det handler om neuro-anatomi. Denne øvelse er en laboratorie-øvelse, hvor de studerende skal “ha’ fingrene på hjernen”, dvs. en våd-øvelse hvor hjernepræparater skal håndteres, og den studerende skal undersøge og identificere forskellige områder i hjernen, eksempelvis: “Hvor er den motoriske hjernebark?” eller “Hvor er hippocampus?” etc. Formålet med øvelsen er, at den studerende skal få en fornemmelse for, hvor store områderne i virkeligheden er, og hvordan forskellige områder placeres i forhold til hinanden og ikke mindst forbindes (og kommunikerer) med hinanden. Dette forstås bedst ved at se den ægte vare. Dette arbejde med neuro-anatomien vil give den studerende en rigtig god ballast ift. den efterfølgende undervisning i kurset, men også på sigt i studieforløbet. Dette er det relationelle niveau i SOLO-taxonomien, som er en del af den kvalitative fase af læringen, og hvilket i Blooms taxonomi svarer til det analyserende niveau (Biggs and Tang; 2007, pp. 64–90).

På idrætsuddannelsen i dag er neuro-anatomi-undervisningen relativt begrænset, og jeg ser her en mulighed for at “lukke et hul”, som kan forbedre undervisning på uddannelsen.

Øvelsen i anden uge omhandler intelligens, intelligenskvotienter (IQ) samt hukommelse. Her er det meningen, at den studerende selv bliver IQ- og hukommelsestestet. Den studerende medbringer sin egen computer, som skal bruges til denne øvelse. Meningen er ikke at finde ud af, hvilket IQ-niveau den enkelte ligger på, men det skal bruges ift. at diskutere og perspektivere, hvad det egentligt er, man tester, og hvordan de forskellige IQ-test forholder sig til hinanden. Endvidere skal de studerende under denne øvelse erfare (og diskutere), hvad forskellen er imellem intelligens og hukommelse, samt hvor og hvordan der er sammenhæng. Det, jeg synes, er særligt spændende, er, at motorisk-IQ er et relativt nyt begreb og er knapt så velbeskrevet som den matematisk-logiske-IQ. De studerende vil under øvelsen blive præsenteret for en model for testning af motorisk-IQ, og derudfra skal de diskutere, hvordan man bedst muligt tester motorisk-IQ. Det er hensigten, at de studerende skal fremsætte en ny eller modificeret model for motorisk-IQ.

Andre konkrete eksempler, der skal arbejdes med i øvelserne, er en del-øvelse, hvor effekten af forskellige indlæringsstrategier testes. I hallen vil de studerende blive udsat for opgaver, hvor der skal trænes ud fra en seriel strategi eller en randomiseret strategi. En anden del-øvelse er at bruge søvn som middel for at forbedre indlæring. Der er flere studier der har påvist at indlæringen forbedres ved brug af efterfølgende søvn-pauser. Dvs. at de studerende i denne del-øvelse skal træne forskellige opgaver (kognitive og motoriske) for at få dybere forståelse for, hvornår søvn har en signifikant effekt for den indlærte opgave, og hvornår det ikke er et effektivt middel.

Alle øvelserne på kurset skal tage afsæt i forelæsningerne og arbejde med pensum. Udover beskrivelsen ovenfor skal øvelserne også være gen-stand for spørgsmål og diskussion ud fra den studerendes niveau. Den studerende skal have en ekstra mulighed for at spørge ind til vanskelige passager i artiklerne (dvs. pensum). Øvelserne skal denne vej igennem fremskynde studenter-centreret undervisning (Level-3-teaching, (Biggs and Tang; 2007, pp. 15–30)) som fremmer læringen.

E-test og eksamen

Der er tre grunde til at e-testene skal bruges.

Det er en god måde at teste de studerende i emner løbende og i hele pensum, uden at det bliver uoverkommeligt. Samtidig kan det være med til at skabe et bedre undervisningsmiljø, hvor de studerende læser pensum løbende og dermed har de en chance for at stille spørgsmål og skabe diskussion/debat.

Jeg stiftede bekendtskab med Absalon i adjunktpædagogikumforløbet og kunne se fordele ved at bruge denne evalueringsform. Endvidere mener jeg, at der er behov for på vores institut (IFI) at udbyde kurser, der bruger internettet som interaktivt medie, og dette vil være et skridt på vejen i den retning. Endvidere bruger de studerende internettet så meget i forvejen, at man sandsynligvis kan forvente, at de føler sig tilpas foran computeren. Med andre ord handler det også om at imødekomme den studerende, der hvor han/hun er, hvilket kan være med til at fremme læringen – altså en måde at nærme sig "Level 3"-teaching, der fokuserer på, hvad den studerende gør (Biggs and Tang; 2007, pp. 15–30).

Det giver mulighed for at evaluere de studerende i de dele af pensum, som ikke egner sig til evaluering i (skriftlig) eksamenssammenhæng – eksempelvis neuro-anatomi. Samtidig med det giver e-testene selve eksamensopgaven et bedre spillerum, hvor de studerende kan vise, at de kan analysere, opsætte hypoteser og konkludere.

I adjunktpædagogikum forløbet blev jeg inspireret mht. brug af test i Absalon. Dvs. der skal kun være en e-test for hver temablok, og de studerende skal besvare 90 % korrekt for at bestå. Består den studerende ikke, så får den studerende præcis den samme test igen. Man kunne spørge om det ikke er kedeligt og ensformigt? Mit svar er nej, fordi anden gang testen tages bliver "opgaven" i virkeligheden at finde ud af, hvor fejlene er, indtil man har styr på det faglige – med andre ord vil temablokkens pensum bearbejdes igen - og gentagelsen skader sjældent forståelsen.

Endvidere vil denne form minimere arbejdsbyrden for underviseren, da der ikke skal laves nye spørgsmål hele tiden. Det vigtigste for e-testene er at sikre, at de studerende er med i pensum løbende og dermed bliver forståelsesprocessen ikke en kortvarig oplevelse dagene op til den endelige eksamen, men noget der indlæres over længere tid, hvilket forbedrer konsolideringen.

Eksamensopgaven skal være en kortere skriftlig opgave, hvor de studerende på begrænset tid viser, at de kan fokusere på opgaven og bruger pensum effektivt til at analysere, sammenfatte, konkretisere og konkludere.

Computerbrug – e-learning.

I forbindelse med indkøring af computerbrug i undervisningen vil jeg bruge Gilly Salmons "Five stage model of online learning" (Salmon; 2005). Reelt vil jeg kun bruge de tre første trin:

- *Access & motivation*
- *Online Socialisation*
- *Information Exchange*
- Knowledge construction
- Development

De to sidste trin er mere beregnet til rene online-læringsmiljøer, hvilket ikke er hensigten i det kursus, jeg beskriver. På den anden side kunne man på sigt tænke en udvidelse af læringsmiljøet ind i den retning, men det kræver lidt mere erfaring.

Sammenfatning af refleksioner og kursets indhold

Kursets vil i store træk starte med introduktion af det faglige indhold og computertekniske forhold. Det faglige indhold starter med et overordnet praktisk perspektiv (motor learning) og fortsætter med mere grundlæggende indhold (neuroanatomi, intelligens- og hukommelseslære) for at give de studerende basisviden. Herefter er indholdet fokuseret på optimering af indlæringen (læringsstrategier), og det bliver en detaljeret fordybelse helt ned på molekylært niveau.

Øvelserne skal sikre "deep learning" sammen med de studerendes egen fordybelse imellem øvelserne. Øvelserne faciliteres af forelæsningerne og under øvelserne arbejdes praktisk. Øvelserne skal sikre kobling imellem teori og praksis via spørgsmål/diskussion.

E-testene skal sikre evaluering i temaerne og være hjælpemiddel til, at de studerende læser undervejs. Det er ikke e-testenes formål i sig selv at sikre deep learning - de skal blot sikre, at de studerende er med i pensum.

Den afsluttende eksamensopgave skal sikre, at den studerende viser det nødvendige faglige niveau samt formulerer, analyserer og konkluderer på baggrund af eksamensspørgsmålet ud fra pensum.

2

Planning and execution of a one-day PhD course employing the theory of didactical situations

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Introduction

In July 2009 I was involved in planning and executing a one-day PhD course in relation to the ULLA Summer School held at FARMA. ULLA is a biannual week-long summer school held jointly by several European institutions of higher learning. It focuses on an array of topics related to pharmacy in a broad sense including biology, chemistry and the social sciences. The title of the course was “Glia: from physiology to pathology”. Including me (LKB) the course team consisted of four teachers and two technical assistants. As indicated by the title the course covered different aspects of biochemistry, physiology and pathophysiology related to glial cells, a specialized cell in the mammalian brain. Eleven students enrolled for the course; however, no information on the educational background of the individual students was available during the planning phase. This, plus the short time available (one day) presented us with significant challenges in terms of settling on a number of issues. Initially, we laid down the intended learning objectives (ILOs) based on our assumptions regarding the expectations from the students. This was not an easy task since we had no information on the composition of the student population; were they all chemists? or biologists? Thus, the problem that I will focus on here is

- how does one, under the conditions described above plan and execute a course with maximum student leaning output as related to the ILOs laid down

The planning phase

The three main issues related to the planning of the course were the following:

- The choice of specific topics to be covered
- The level of detail of the individual topics including description of the ILOs
- The teaching and learning activities (TLAs) including appropriate didactical considerations as related to the ILOs

The choice of topics

With regard to the topics we chose the pragmatic approach of only including topics that were within our fields of expertise in terms of research. One disadvantage of this decision was that the students would then only be introduced to a narrow aspect of glial biology; however, as it was a short course we thought it better to cover a few specific topics rather than trying to cover the whole field. One major advantage was that we could focus more on the quality of the teaching rather than preparing broad lectures that included topics that were really out of our field of expertise.

The final program consisted of the following components:

- Introduction to glial cells
- Glial cells, normal function
- Lab exercise
- Glial cells, pathological aspects
- Class exercise

First, a general introduction to the field was give followed by two separate lectures on the role of glia in normal function. The following lab exercises were designed to illustrate key points of these two lectures. The lab exercise included a subsequent class exercise in which the students were asked to interpret the results obtained employing knowledge acquired from the lectures. Finally, two lectures were given on pathological aspects of glial function. The rationale for this design was (1) that the students were given an overview of normal function before the pathology was discussed; (2) that the lab and class exercises were placed so that they provided a break from the lectures; (3) that the lab and class exercises would complement and expand on the aspects covered in the lectures; and finally, (4) that the program should present as a coherent series of TLAs going from the broad introduction (lecture) to the final class exercise where the students should be able to work independently (including *adidactical situations* as elaborated below) with the results from their lab exercise.

The level of detail

As mentioned, several factors made it rather difficult for us to describe the ILOs and settling on the level of detail for the course. We chose to assume that we were dealing with PhD students with a background in pharmacy. Thus, we would not expect them to have any detailed knowledge of glial cell function but merely a general understanding of biochemistry and a superficial knowledge of brain function. With that in mind we formulated the following ILOs:

By the end of the course, the students

1. …should have a *superficial* understanding of glial biology
   - Know the different subgroups of glial cells
   - Basic knowledge of the amount and distribution of glial cells in the brain
   - Basic knowledge of the morphology of glial cells
   - Basic knowledge of the the role of glial cells in relation to neurotransmission
2. …should have a somewhat *detailed* understanding of glial function within the narrow topics covered
   - Knowledge of the role of glial cells in neurotransmitter homeostasis including nitrogen homeostasis; specifically the “nitrogen problem” related to the glutamate-glutamine cycle
   - Knowledge of the energy-generating pathways fueling neurotransmitter (glutamate) uptake
   - Knowledge of current and future drug targets within intermediary metabolism and neurotransmitter (GABA) transport for treating epilepsy
   - Knowledge of the role of glial cells in neuropathic pain and putative drug targets

3. ...should be able to independently *interpret* experimental data of low complexity with regard to glial function within the topics covered
   - Be able to interpret data from simple uptake assays of glucose and neurotransmitter uptake in cultured glial cells
   - Based on the use of specific inhibitors of glial metabolism, the students should be able to differentiate between the roles played by distinct energy-generating pathways for fueling uptake of neurotransmitter
   - Be able to suggest novel experiments to elucidate aspects of energy metabolism in cultured glial cells

Even though it was rather unconventional, we chose ***not*** to reveal the ILOs to the students. We did this because we thought it would be overwhelming for the students to be presented with ILOs for a one-day course that did not include an actual evaluation of whether they fulfilled these or not. Thus, the ILOs were only used as an *internal reference* for the teachers. The teachers aimed at fulfilling these ILOs and to set the level of the TLAs accordingly. We sent out a few review papers as pre-course reading material; however, we planned the teaching under the assumption that the students were largely unprepared.

The teaching and learning activities

Since we are experimental scientists, we decided early on that the course should include both lectures as well as practical exercises/tutorials. The purpose of these was to support the learning process related to ILO (2) and fulfill ILO (3). My specific responsibility was to give one of the lectures in the morning on a specific topic plus to plan and execute the lab and class exercises. For my part, I decided to plan the teaching according to the *theory of didactical situations* (TDS) by Guy Brousseau as described by Winsløw (2007) and Christiansen and Olsen (2006). In short, TDS is concerned with the creation of a so-called *didactical milieu* (DM) in which the students may work independently with a given problem in a way that enables them to reach the intended level of learning (that is, the ILOs) partly on their own. Thus, the teacher provides the DM by giving the students the first few pieces of the puzzle and then, during the so-called *adidactical period* the students may put the remaining pieces together themselves. During the adidactical period the students work independently of the teacher. At the end of the session, the teacher then ensures that the students arrived at the “right” answers; this might be done by discussing the output from the students in plenum. The central dogma in TDS is that the established “text-book” knowledge needs to be “personalized” by the students by providing the proper DM; i.e. the teacher should create a DM that enables the students to establish this knowledge on their own. The introductory lecture given prior to the adidactical period is referred to as *devolution*; here, some of the established knowledge is transferred from the teacher to the students and the ground rules for the adidactical period are laid down. The last part where the teacher is discussing the answers with the students is referred to as *institutionalization* of the knowledge they obtained during the adidactical period. The teacher should strive to put the knowledge obtained into the proper framework or context for the purpose of generalization.

Execution and intrinsic evaluation of the course

In practice, we planned the two morning lectures to give just enough information so that the students should be able interpret the results from the lab exercise on their own. In addition, I included an exercise during my lecture in which the students were asked to come up with one or more solutions to a problem. The students were presented with the problem and then given 10 min to think about the possible solutions. They were allowed to discuss the problem among themselves. The problem was designed to illustrate a central part of cellular metabolism and cellular interdependence between nerve cells and glial cells; basically, they were asked to imagine that they were *intelligent designers* and come up with the best way for the cells to deal with the issue. The students were very eager to take part in the discussions and they were able to come up with two solutions that were more or less identical to the “right” ones. The solutions are actually not “text-book” knowledge but rather issues that are still being debated within the field; thus, none of the students would be expected to have any prior knowledge about this. The objective of this exercise was to prime the students for the lab/class exercise ahead and to my best of knowledge we succeeded in doing that.

The lab exercises were kept very simple. All materials were provided beforehand and the exercise itself lasted about 40 min including introduction and execution of the experiments. The students were divided into three groups of three or four people. After the afternoon lectures, the students were handed the results of the experiments and given about one hour to interpret the results (the adidactical period; no teachers present) in the context of what they knew from the morning lectures and any other sources of information. They were also asked to come up with new experimental designs to elucidate aspects not covered in the experiments performed. After this the interpretations and ideas for new experiments were discussed in plenum. In practice each group presented their experimental results and their interpretations/hypotheses/ideas and then this was discussed in plenum in a milieu supervised/controlled by the teachers. Finally, the teachers gave a short, interactive lecture in which the experimental work and the theoretical matters were put in to a larger perspective focusing on how it relates to disease research and drug development.

As far as the teachers were concerned, we believe that the course was well-executed and succeeded in the goals (i.e. as related to the ILOs) that we set up. However, since there was no formal assessment of the students we have to rely on the course evaluation forms handed in by the students for evaluating whether we reached our goals or not. In general, the student evaluations were good which is best exemplified by the fact that all eleven students would recommend the course to others! Nine students thought the course met their expectations and only one student reckoned the level of the course was too high. Furthermore, the topics were characterized as either *interesting* or *very interesting* and only two students found that topics were missing (both would have liked more background information on glial cells). This is a clear indication that the level and topics were well chosen and by extrapolation that the ILOs were met. With regard to the teachers/teaching methods most students regarded these aspects as being of good quality; three students regarded the methods as being *excellent*. This indicates that the teachers did well; however, there is room for improvement. Since very few written comments were made it is hard to say exactly which parts of the teaching were good/excellent. It should be mentioned that only two of four teachers chose to do interactive lectures whereas the other two chose to do conventional lectures with a low level of student interaction. Thus, it is hard to know exactly how my own teaching was evaluated by the students.

Conclusion

Since the student evaluations suggested that the course was well executed, I believe that we succeeded in organizing a successful course under the conditions that the ULLA Summer School posed on the teachers/organizers. In summary, to organize a course under these conditions it is important to focus on a narrow rather than a broad aspect within the field. Furthermore, the level should be rather basic to fit with the average PhD student within the pharmaceutical sciences (in this case, basic knowledge of biochemistry and superficial knowledge of brain function); clearly, the ILOs and the TLAs should be chosen to reflect this. As a final point, one aspect that seemed to be important for the success of this course was the lab & class exercises organized according to TDS. Here, it is important that the individual elements are simple in the sense that they focus on central elements of the subject that may be generalized to the subject field.

Finally, I would like to state that I find TDS to be very suited for designing courses and teaching sessions at this level and that I plan to make use of the experiences gained from this course in my everyday teaching at university level.

3

New course in Protein Structures in Drug Research

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Introduction

This project describes my reflections on my involvement in the planning, execution and student evaluation of the one-day course: “Three-dimensional Protein Structures in Drug Research”. The course is part of the ULLA summer school for PhD students and since this was the first time the course ran I had a unique opportunity to influence the planning of the course. I was not formally responsible for organizing the course, however, the relevant person gladly gave me the chance to influence planning as much as I wanted to.

Background – The ULLA summer school

The ULLA summer school is a biannual event that aims to “widen [. . .] knowledge of updated key issues regarding for instance drug discovery, drug development and the economic and management issues” and “it gives postgraduates an optimal opportunity have a great time and to create an international network” (European University Consortium for Advanced Pharmaceutical Education and Research; 2002). ULLA is a collaboration between European pharmaceutical universities (originally Uppsala, London, Leiden and Amsterdam).

Student background

The summer school is aimed at PhD students and since the content of pharmaceutical education is (at least partly) regulated by an EU-directive the student population is relatively homogeneous.

This year's summer school was attended by 151 students and consisted of approximately 50 one-day courses in five days plus a social program.

This means that we as teachers should be prepared to deal with students that might (a) be here primarily for the social part of the summer school, (b) not have had this course as their first priority. Obviously, this means that we should put special emphasis on motivating the students for the teaching activities that we would like to undertake.

Theoretical considerations

Constructive alignment

The theoretical framework I chose to implement in the course is known as constructive alignment (Biggs and Tang; 2007). This is a concept that can be boiled down to one sentence: The most efficient learning takes place when you are doing what you should learn.

An example could be writing. The best way to learn writing is to actually do it. Obviously, there need to be some feedback so that spelling mistakes can be avoided, language can be improved and style can be made more elegant.

To teach within the framework of constructive alignment requires some considerations before planning the teaching. These will be summarized in the following sections.

Intended learning outcomes

Probably the most important step in all teaching is to identify what the students should actually benefit from your teaching. In the context of constructive alignment this is even more important to consider carefully. Since the whole point is that the students should do what they are intended to learn it is necessary to define the intended learning outcome (ILO) as something that can be performed. It cannot be a too diffuse outcome such as "the students should be able to understand this and that", but rather must be concrete as in e.g. "the students should be able to write without making spelling mistakes". This is both a skill that can be acquired by the right tutoring and an action that can be performed while learning it.

Teaching and learning activities

Since the ILOs in constructive alignment has a built-in action this very much determines what the teaching and learning activities (TLA) should be. The idea is that the teaching should be primarily student centered so they are engaged in the activity they are supposed to learn. The teaching and learning activities is thus already defined in the intended learning outcomes.

Planning of the teaching

Before I was involved in planning the course a course description (appendix A) had been prepared. This formed the basis for the planning of the course and what the students would expect from it since the students had used this for applying for it. It also required that the students had a basic understanding of protein structures and together with the considerations in the section on student background this would ensure a relatively homogeneous student population.

Motivation

For reasons described previously it could be expected that the students would not be extremely motivated to be engaged in learning activities and particularly not in student centered activities. Therefore, we were keen on planning the teaching in a way that made the activities seem meaningful to the students. The way we did this was to use a recurring theme throughout the day. This theme was a piece of work from our own lab where exactly the methods that we would like to teach the students were used to derive some very interesting results. It was our hope that this would motivate the students to engage in the learning process.

Intended learning objectives

The course description in Appendix A describes a number of subjects that the course will cover. However, these points are not suitable as intended learning objectives. So the first part of the planning was to define a (low) number of learning objectives that could be used to design the teaching and learning activities. This resulted in the following ILOs:

The students should be able to:

1. design, perform and evaluate a crystallization experiment
2. analyze molecular contacts between proteins and drug related compounds
3. critically evaluate the quality of a protein structure in the Protein Data Bank

These three (or five, depending on how you look at it) learning objectives are relatively well-defined and easily forms the basis for TLAs. They are constructed in a way that the students will automatically encounter the subjects they have been promised in the course description.

Teaching and learning activities

As the theory in constructive alignment dictates, the ILOs stated above determines the TLAs that will take place. One general problem in this particular course is obviously that a rather broad range of subjects will be covered in only one day. This will automatically have the consequence that the ILOs will not be covered as thoroughly as we would wish. One could argue that this should make us lower the ambition level by cutting down on the number of ILOs. However, the nature of the course as a one day event where no one expects that the students learn the subject to a deep level of understanding, in our view, justifies the ambition level.

As described below the program for the day (Appendix B) was designed as a mix of laboratory and computer exercises interrupted by two lectures. One of these (45 minutes) was a case story where the story behind the recurring theme was presented, the other a short (20 minutes) theoretical lecture on protein-ligand interactions that was necessary for the understanding of the following computer exercise.

Let us take a look at how the ILOs were used to design TLAs one by one:

Design, perform and evaluate a crystallization experiment

This part was started by a short introduction (10 minutes) where some practical aspects of crystallography were covered as well as some theory behind protein crystallization. After this we used approximately 20 minutes on discussing how to set up a specific crystallization experiment where I tried to keep my mouth shut as much as possible. After that the students were handed a recipe for eighteen crystallization experiments where they were told to choose six to perform. Optimally they should have made the recipes themselves, but this was skipped due to time constraints. They then performed the actual crystallization experiment. Due to the nature of these experiments (the crystals take time to form) the evaluation was the last item on the program. The protein they performed the experiment on was the same as covered in the case story and as such a part of the recurring theme.

Analyze molecular contacts between proteins and drug related compounds

This exercise was a recycled one that has been used with success in another course. During the exercise the students are guided through the steps of analyzing a protein-ligand complex much the same way as we "professionals" would do it. This is the only part of the course that is not specifically designed for this course and therefore the subject protein is not part of the recurring theme, but a closely related one.

Critically evaluate the quality of a protein structure in the Protein Data Bank

In this exercise the students were asked a number of questions that were designed in such a way that they were required to discuss among themselves the concepts that were presented. These concepts are obviously the ones that are important for evaluating quality of protein structures. During the exercise the students compared a high and a medium quality structure and in this way they should learn how to distinguish between these types. The exercise ended with a plenum where doubts were clarified.

Student evaluation

Just prior to the end of the day the students were handed a questionnaire for evaluation of the course. The results are summarized in Appendix C.

Overall the evaluation seems to be quite positive. Personally, I am quite pleased that only two persons found that the level of the course was too high. Looking through these two particular evaluations it is evident that the two students are generally displeased with the course and they also give a reason: They are annoyed at a particular computer program they have encountered during an exercise. This identifies the two persons and I remember the incident that created the frustration which was that they did not ask for the readily available help (we were three teachers for seventeen students) and instead became obsessed with a particular problem. I really do not know how to avoid a situation like that.

Since this project is an exercise in employing efficient teaching methods it also seems pleasing that the response to the question how they would rate the teaching methods employed in the course is so positive. However, I know why they are so positive because several students told me during the day: “Ah, finally some lab work”. I would also have been satisfied with a slightly less positive response as this is not a popularity contest, but a question of making teaching and learning activities that are efficient.

A Appendix: Course description (excerpt)

Course for ULLA Summer School 2009
Course title (short and descriptive): **Three-dimensional protein structures in drug research**
Course leader: name: **Karla Frydenvang** title: **Associate professor** organisation: **Biostructural Research, Dept. of Medicinal Chemistry, FARMA, KU** e-mail: **kf@farma.ku.dk**
Teaching staff (names on 1-2 colleagues, who you plan to organise the course with): **Professor Jette Sandholm Kastrup** **Post doc Peter Naur**
Specific facilities needed (besides room, blackboard, overhead projector, and projector/beamer): **Laptop computers**
Course description (max. 1/2 page or 300 words): **The last decade has brought tremendous progress in our understanding of the structural and mechanistic details of many proteins. This insight has greatly advanced the ability to perform rational drug design of compounds with improved selectivity profiles and/or pharmacological properties. Unlike the traditional drug discovery method – defined as the trial-and-error testing of arbitrary compound selections for a given biological function – structure-based drug design begins with a knowledge of the specific target, e.g. structure of the specific protein of interest, and hereafter tailoring compounds with certain properties based on this knowledge.** **The aim of the course is to introduce experimental methods, which can be used to analyze molecular characteristics of biologically important molecules, and to understand the interactions between ligands and drug related compounds.** **The course will cover the following aspects:** • **crystallization of proteins with drug related compounds** • **evaluation of results achieved from x-ray structure determination of proteins** • **introduction to important databases** • **analysis of molecular characteristics of biologically important molecules** • **analysis of interactions between proteins and drug related compounds** • **structure-based drug design** **The course will have lectures in the morning session and practical workshops on crystallization of a protein with a drug related compound and computer analysis of protein-compound interactions in the afternoon session.**

B Appendix: Course program

Three-dimensional Protein Structures in Drug Research

ULLA Summer School – Copenhagen 2009

Friday July 3rd

Program:

9:00 – 9:15:	Introductory remarks
9:15 – 10:30:	Exercise in crystallization
10:30 – 10:45:	Coffee break
10:45 – 11:15:	Exercise in crystallization - continued
11:15 – 12:00:	Case story – Search for a ligand for GluRdelta2
12:00 – 13:30:	Lunch
13:30 – 13:50:	Introduction to protein-ligand interactions
13:50 – 15:00:	Computer exercise on protein-ligand interactions
15:00 – 15:15:	Coffee break
15:15 – 16:15:	Computer exercise in protein structure databases and structure quality evaluation
16:15 – 17:00:	Evaluation of crystallization experiment

Teachers:

Assoc. Prof. Karla Frydenvang, kf@farma.ku.dk

Post.doc. Peter Naur, pna@farma.ku.dk

Professor Jette Sandholm Kastrup, jsk@farma.ku.dk

Department of Medicinal Chemistry, Faculty of Pharmaceutical Sciences,

University of Copenhagen, Universitetsparken 2, DK-2100 Copenhagen, Denmark.

C Appendix: Student evaluation

2. Did the course meet you expectations	No	To some extent	Yes	Absolutely	No answer
		3	9	5	1
3. How would you rate the course material	Poor	Satisfactory	Good	Excellent	
	2	3	10	3	
4. How would you rate the level of this course	Too low	Good	Too high		
		14	2		1
5. How would you characterize the topics addressed at this course	Not interesting	Interesting	Very interesting		
		10	7		1
6. Did you find any topics missing in this course	No	Yes			
	18				
7. How would you rate the teaching methods of this course	Poor	Adequate	Good	Excellent	
		1	12	4	1
8. How would you rate the teachers at this course	Poor	Satisfactory	Good	Excellent	
		1	12	4	1
9. Would you like to recommend this course to others	No	Yes			
	1	17			
10. Did you look at the course material prior to arrival	No	Yes			
	11	7			

4

Planlægning af nyt kursus i ornitologi på biologistudiet, KU

Kasper Thorup

Zoologisk Museum, SCIENCE, Københavns Universitet

Introduktion

Der er i øjeblikket ikke noget specialiseret kursus i ornitologi på Københavns Universitet. Et sådant kursus har tidligere været afholdt på KU indtil starten af 90erne og har desuden været afholdt på Aarhus Universitet indenfor de seneste år – begge steder med pæn søgning. Der er stor interesse blandt de studerende for at få mulighed for at beskæftige sig mere indgående med fugle. Denne interesse dækkes meget nødtørftigt på den obligatoriske del af biologikurset. De studerende har mulighed for at tage bachelor-kurset, Danmarks Fauna – Hvirveldyr, der indeholder en grundig introduktion til de danske fugle og deres biologi (undervisningen på den to uger lange ornitologi-del varetages af undertegnede). Et egentligt ornitologikursus vil derfor give de studerende en god mulighed for at arbejde videre på denne introduktion.

Generelt udviser de studerende stor interesse for de højere dyr, som eksempelvis hvirveldyr og fugle, og langt de fleste amerikanske universiteter udbyder da også ornitologi- og/eller mammalogi-kurser. Kurset, Danmarks Fauna – Hvirveldyr, hører til de allermest søgte valgfri bachelor-kurser, i 2009 med 72 tilmeldte, og en stor del af de studerende herfra giver udtryk for, at de gerne vil have mulighed for at arbejde videre med beslægtede emner.

Ornitologien har, på grund af den store mængde basisviden på området, i mange år været førende indenfor mange grene af den biologiske forskning, og det er derfor højest relevant, at de studerende stifter kendskab til ornitologi og ornitologisk metoder.

Formålet med at tilbyde et ornitologikursus er at give de studerende et grundlæggende kendskab til ornitologien, og derved give dem mulighed for at arbejde videre med dette i andre sammenhænge, for eksempel et speciale. Derudover vil der være fokus på at "klargøre" de studerende til senere specialeskrivning, med fokus på at opnå erfaring i kritisk læsning af artikler, artikelskrivning, kvantitative analyser og statistiske konklusioner. På kurset vil de studerende blive introduceret til aktiviteterne på Ringmærkningscentralen og en række centrale aktiviteter på Statens Naturhistoriske Museum: samlinger, præparation, fylogeni, taxonomi og identifikation, og de vil derved have bedre grundlag for at vurdere muligheden for senere at skrive speciale på SNM.

Dette projekt indeholder beskrivelsen af et nyt kursus i ornitologi på Københavns Universitet med kommentarer og refleksioner både teoretisk og praktisk, bl.a. en diskussion af hvilke kompetencer de studerende har opnået på bachelor- og kandidatstudiet på biologi i forhold til, hvad der kræves af de studerende ved specialeskrivning og efterfølgende opgaver.

Grundlag for kursusplanlægning

Kursusplanlægning er sket med udgangspunkt i (Jakobsen; 1999), men også relevante dele af (Biggs and Tang; 2007) samt (Horst and Winsløw; 2004).

Tidligere tiders undervisning har haft en stærk fokusering på indholdet af kurserne: hvilke stofområder skal dækkes og hvordan skal det præsenteres for de studerende. Den mere moderne opfattelse af undervisning og læring, der bl.a. er det gennemgående tema i (Biggs and Tang; 2007), er mere fokuseret på hvad de studerende lærer (outcome-based) og hvordan de lærer det (Level 3 teacher: what the students DO) med målet for undervisningen at skabe de bedste rammer for de studerendes læring. Da det har stor betydning for, hvordan lærerne undervisningen foregår i praksis har det selvfølgelig også stor betydning for, hvordan undervisningen planlægges. Derudover er der yderligere helt specifikke forhold, som kommer til at indgå i undervisningsplanlægning, der ikke indgår i den traditionelle undervisningsplanlægning, idet lærerens overvejelser i høj grad skal gå på at definere læringsmål og dertil "skræddersyede" læringsaktiviteter. I dette indgår også, at læringsmål, der tidligere var mere eller mindre eksplicitte, skal formuleres og adresseres i undervisningen og eksamen (alignment). Dette gælder eksempelvis mere overordnede evner, som at tænke tværfagligt, eller formulere og beskæftige sig med nye problemstillinger.

Den moderne opfattelse af undervisning bygger oftest på en konstruktivistisk tankegang, hvor viden betragtes er noget, der konstrueres på baggrund af individets egne oplevelser og aktiviteter, enten individuelt eller i social sammenhæng. Derved betragtes de studerendes aktiviteter som mere betydende, for hvad de lærer, end hvilket stof de præsenteres for! Disse principper kaldes tilsammen for "constructive alignment" (Biggs and Tang; 2007).

De første overvejelser i forbindelse med planlægningen af et kursus vedrører således hvilke kompetencer, man som lærer ønsker, at de studerende skal bibringes via kurset. Kompetencerne beskrives som læringsmål (Intended Learning Outcomes, ILOs), og består af to dele: et emne/indhold og et niveau af viden, der typisk beskrives med et verbum. Ved niveauet af viden skelnes eksempelvis (Jakobsen; 1999) mellem at kunne (1) gengive facts og metoder og løse standardopgaver, (2) anvende principper og metoder til løsning af andre problemer en det, hvor de er lært og (3) løse komplekse praktiske problemer, hvor 3 er det mest krævende. Flere forskellige systemer (taxonomier) eksisterer til at beskrive det niveau af viden, der ønskes opnået. Jeg har primært brugt verber fra Blooms taxonomi, der opdeler vidensniveauerne i remembering, understanding, applying, analysing, evaluating og creating. En præcis beskrivelse af læringsmålet fås derfor med en kombination af et verbum, der beskriver niveauet samt dets indhold, som for eksempel: "de studerende skal efter kurset kunne (1) *beskrive* alle danske fugle, (2) *anvende* metoder indenfor ornitologien og (3) *designe* et projekt til test af en hypotese indenfor ornitologien".

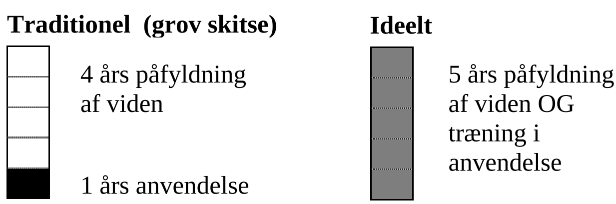
Valg af kompetencemål

Kurset har som et vigtigt formål, at forberede de studerende til at kunne vælge et speciale indenfor ornitologi. For at de studerende kan være velforberedte til specialeskrivning er der primært to dele, som de studerende har brug for: (1) et udbygget kendskab til ornitologien og (2) generelle kompetencer til at tackle biologiske problemstillinger.

De studerende har kun stiftet meget begrænset kendskab med ornitologi gennem deres studie, primært fra bachelor-kurserne "organismernes diversitet" (én dag, tvunget) og "danske hvirveldyr" (2 uger, valgfrit). Valget af kompetencemål indenfor dette vil derfor primært være rettet mod at øge deres kendskab til ornitologien og dens redskaber og metoder og underdiscipliner.

I forhold til (2) er kompetencerne mere uklare. I et 1-årigt specialeforløb på biologistudiet trækkes der på en række generelle kompetencer, og mange af disse er også essentielle for den færdiguddannede kandidat. Den studerende vil skulle sætte sig ind i original faglitteratur specifikt for det valgte område og udføre et selvstændigt studie indenfor dette område. Der vil således være trækkes på kompetencer rettet mod at kunne forstå og sætte sig ind i faglige studier og evaluere dem kritisk, at kunne designe løsningsmodeller og regne på dem samt afrapportere resultaterne af studiet og sætte dem i perspektiv skriftligt.

Mine egen erfaring fra biologistudiet (1997-04) er, at der kun var meget begrænset fokus på disse kompetencer på studiet. Yderligere er min erfaring med de (relativt få) specialestuderende, jeg har vejledt og fra min øvrige undervisning, at der foreløbig ikke er sket de store ændringer på dette punkt. Der er gennem hele vejledningsforløbet brug for at hjælpe de studerende til at opnå rimelige kompetencer indenfor de ovenfor nævnte områder. Jeg vurderer derfor, at der i høj grad har været tale om at dække brede områder af biologien uden at opnå vigtige generelle kompetencer, med stort set fire års "hælden" viden på og kun et år til at tilegne sig de vigtige kompetencer. Heroverfor står den mere moderne "alignede" undervisning, hvor de studerende har beskæftiget sig med både faglige og generelle kompetencer gennem hele studiet.



Der er dog ikke tvivl om, at der efter den seneste reform af studiestrukturen i 2003 ER sket forbedringer på dette område. En gennemgang af de obligatoriske kurser afslører dog, at ovenstående emner her kun behandles meget overfladisk (se appendix B). Et andet problem er at et kursus som matematik/statistik i høj grad er løsrevet fra biologien. Studerende på andet år på Danmarks fauna – hvirveldyr døjer således med store problemer med at forstå, hvordan statistiske resultater kan tolkes.

På de valgfrie kurser er der en større tendens til, at disse emner indgår og trænes. Jeg har kigget nærmere på kurser, som vil være naturlige for en organismeinteresseret evolutionær økolog med fokus på vertebrater (Appendix A). Flere valgfri kurser på biologiuddannelsen har læringsmål, der retter sig mod disse mål, men typisk er undervisningsaktiviteterne ikke specielt målrettede.

I. Krav	II. Mål for obligatoriske/ valgfri kurser	III. Primære TLAs p.t. (postulat!)	IV. Foreslåede TLAs
Alle kandidater			
(1a) Kunne forstå og sætte sig ind i faglige studier	God	Præsentation af ”viden” (tekstbøger, forelæsninger/øvelser)	Præsentation af nødvendig baggrundsviden
(1b) Kunne evaluere faglige studier kritisk	%	Mere eller mindre tilfældig læsning af udvalgte ”gode” originale studier	Læsning og selvstændig evaluering af ”gode” og ”dårlige” artikler
(2) Kunne angive løsningsmodeller for faglige problemstillinger	%	Oftest øvelser med ”præfabrikeret” løsning	Foreslå og kritisk evaluere potentielle løsninger
(3) Kunne regne på data til løsning af faglige problemstillinger	%	Gennemføre udregninger med ”præfabrikeret” løsning	Regne på foreslåede løsningsmodeller (f.eks. i Excel)
(4) Kunne afrapportere faglige studier skriftligt	OK	(Bachelor-projekt)	Skrive dele af artikler/rapporter (abstract, intro, methods, results, discussion, etc.) og hele artikler/rapporter, gerne på engelsk
Kun forskere			
(5) Kunne stille interessante/relevante faglige spørgsmål og opstille hypoteser	%	%	På baggrund af opnået viden at formulere interessante faglige spørgsmål/hypoteser

Figur 4.1. Skematisk fremstilling af kravene til kandidaternes kunnen og hvordan den obligatoriske undervisning relaterer til dette.

Kurserne “Forsøgsplanlægning og eksperimentel metodik i økologi” og “Eksperimentelt økologisk projektarbejde” angiver eksempelvis, at studenten efter kurset skal kunne, ud fra en økologisk problemstilling, “opstille testbare hypoteser, planlægge og udføre et forsøg, samt lave beregninger og statistiske tests". Og samlet vil disse to kurser uden tvivl give en rigtig god træning. Der er dog kun i begrænset omfang muligt for de at studerende at vælge problemstillinger selvstændigt, og disse foreslås normalt af læreren. Desuden har kurserne kun begrænset interesse for en organisme-interesseret evolutionær økolog med fokus på vertebrater.

For flere af kurserne er det kendetegnende, at færdigheder kun i begrænset omfang "trænes"/"øves". At gentagne gange diskutere interessante problemstillinger eller løsningsdesign i et åbent forum, hvor læreren indgår som vejleder, er oftest bedre, end at eleverne gennemfører et helt studium fra A til B, hvor den eneste mulighed for at dette kan lade sig gøre er, at læreren har planlagt forløbet.

På kurserne biodiversitet og conservation, og ikke mindst kandidatkurserne makroøkologi og evolutionær økologi, indgår en række elementer, der understøtter de mere generelle færdigheder, og her er der vægt på at gentage de vigtigste læringsprocesser.

Et andet problem, som går igen på flere kurser, er anvendelsen af eksempelvis meget fagspecifik software. Herved får de studerende kun begrænset træning i at tænke og regne selvstændigt, og de mangler redskaber til hurtig generel datahåndtering og beregninger, som man opnår ved intensiv brug af regneark som Excel.

Den nuværende studieordning på bachelordelen af biologi indeholder følgende læringsmål:

Faglige kompetencer

1. kan anvende og vurdere basale biologiske metoder
2. kan demonstrere indsigt i centrale biologiske discipliner, teorier og begreber
3. har kendskab til de vigtigste organismegruppers økologi, fysiologi og taxonomi

Anvendelseskompetencer

4. kan anvende apparatur til almene biologiske analyser
5. kan planlægge og udføre biologiske projekter og eksperimenter
6. kan analysere praktiske biologiske problemstillinger i en erhvervsmæssig/professionel sammenhæng
7. kan træffe og begrunde fagligt relaterede beslutninger.

Omverdenskompetencer

8. kan vurdere biologiske problemstillinger i samfundet på et videnskabeligt grundlag
9. kan vurdere signifikansen af biologiske sammenhænge i en erhvervsmæssig og økonomisk sammenhæng.

Personlige kompetencer

10. kan beskrive, formulere og formidle biologiske problemstillinger og resultater i en videnskabelig sammenhæng
11. kan foretage biologiske analyser ved brug af videnskabelig metode
12. kan arbejde individuelt såvel som i gruppesammenhænge med praktiske og teoretiske biologiske problemstillinger
13. kan strukturere egen læring og kompetenceudvikling.

Disse læringsmål dækker efter min mening udmærket de krav, som der stilles ved start på specialeskrivning. Men som ovenstående gennemgang viser, er spørgsmålet, i hvilket omfang de adresseres i den undervisning, der tilbydes/vælges af de biologistuderende. For eksempel mål 7 (kan træffe og begrunde fagligt relaterede beslutninger) og 8 (kan vurdere biologiske problemstillinger i samfundet på et videnskabeligt grundlag) er noget, som de studerende sandsynligvis vil møde i en eller anden form, men det er ikke tvunget og heller ikke på nogen måde trænet.

Læringsmål og undervisningsaktiviteter specifikt for at klargøre studerende til specialeskrivning

På baggrund af ovenstående finder jeg det derfor særdeles relevant i et ornitologikursus, at i høj grad have fokus på kompetencemål der skal forberede de studerende på et selvstændigt specialeprojekt og en senere karriere som biolog med fokus på terrestriske vertebrater.

Som specifikke læringsmål på et ornitologikursus har jeg derfor inkluderet følgende mere generelle læringsmål, men dog med udgangspunkt i ornitologien:
The student will after the course be able to:

- Evaluate scientific ornithological papers
- Define ornithological questions and devise solutions

- Describe ornithological methods and apply a selection of these methods
- Analyse ornithological data sets
- Reflect on the solution to ornithological problems and general inference

Planlægning af specifikke undervisningsaktiviteter

Ved planlægningen af de specifikke undervisningsaktiviteter, har jeg primært taget udgangspunkt i Biggs and Tang (2007), Jakobsen (1999) og Horst and Winsløw (2004). Derudover har jeg inddraget en del tanker fra Schilling (2001) om åbne problemstillinger og "virkelig" videnskab.

Ved læring er de studerendes aktiviteter i fokus, og det er vigtigt at være opmærksom på hvilken type læring ens aktiviteter opfordrer til. Man skelner mellem "deep" og "surface" tilgange til læring, hvor udenadslære og tendensen til at forsøge at komme hurtigst og lettest muligt igennem et kursus er typiske eksempler på overfladisk læring, som man som lærer i de fleste tilfælde vil være interesseret i at undgå. Heroverfor står tilgangen med studerende, som finder indhold og kursus interessant og arbejder med en dyb forståelse af stoffet. Traditionelt har man fokuseret på de studerendes "egen" tilgang i denne henseende (gode vs. dårlige studerende), mens man i dag i langt højere grad fokuserer på undervisningens potentiale til at fremme dyb læring.

Dette er i høj grad et spørgsmål om de studerendes motivation, men der er flere måder, hvorpå denne kan påvirkes gennem undervisningen ("motivation follows good learning as night and day", (Biggs and Tang; 2007)). En af de vigtigste forudsætninger er at rammerne er gode for de studerendes læring. En høj grad af tillid til de studerendes egen formåen og frirum til at tænke og dele tanker er essentiel for at skabe et ideelt læringsmiljø "Theory Y climate", da det jo er de studerendes egen forståelse, der er i centrum.

Biggs and Tang (2007) argumenterer for, at god undervisning der aktiverer de "ugidelige" elever ("Roberts"), også egner sig til at stimulere de mest motiverede og "dygtige" elever. Jeg er dog tvivlsom overfor dette, og mener at det fortsat er vigtigt at have fokus på at stimulere de bedste elever. På sin vis ser jeg her en modsætning mellem universitets fokus på økonomi og dermed på hele studentermassen og lærerens ønske om at få engagerede studerende indenfor ens felt. Definitionen af bedste elever er dog et langt vanskeligere spørgsmål. Flere af de folk, der de senere år er blevet fastansat på Biologisk Institut og Zoologisk Museum, har eksempelvis ikke hørt til de “bedste” studerende. Der har snarere været tale om exceptionelt motiverede folk, der har prioriteret benhårdt.

Jeg er selvfølgelig helt enig med Biggs and Tang (2007) i, at der skal være stærk fokusering på hvad de studerende gør, frem for hvad de skal lære. Alligevel mener jeg, at der er grund til at læreren skal være opmærksom på, at ikke alle undervisningsformer tiltaler studerende lige meget. Min egen personlige erfaring er, at der er forskel på, hvordan de forskellige studerende arbejder. Det betyder ikke nødvendigvis, at der skal tages hensyn til dette i undervisningen (jævnfør kritikken af de såkaldte “learning styles”), men i hvert fald at læreren må være åben overfor de studerendes tilgang.

Jeg vil argumentere for, at læreren må være så åben så mulig overfor de studerende, deres individuelle arbejdsmetoder og deres “potentiale”. Det svære ligger i udformningen af opgaverne, så alle kan finde udfordringer i opgaven, men ønsket om at det hele skal være succesoplevelser må ikke forhindre at de bedste også udfordres.

Specifikke undervisningsaktiviteter

Jeg har valgt i høj grad at fokusere på det, som Schilling (2001) kalder åbne undersøgelser, “virkelig” videnskab. At give de studerende mulighed for at stifte bekendtskab med autentiske problemstillinger og de forhold som de løses under. Der er ikke nødvendigvis tale om meget åbne hele forløb, fra problemstilling til endelig løsning og afrapportering, men snarere at gå ind, og beskæftige sig med de enkelte dele, og her træne de studerende med mindre oplæg og diskussion.

Jeg har derfor valgt at fokus undervisningen på tre emner, som i høj grad er vigtige for de generelle kompetencer: kritisk artikellæsning, øvelser i dele af den “virkelige videnskabelige proces” og et selvstændigt studium (i grupper), alle tre naturligvis med udgangspunkt i ornitologien:

- Journal club med artikler indenfor gennemgåede emner og aflevering af essays
- Mindre diskussionsøvelser med udgangspunkt i tekstbogen eller artikler
- Gruppearbejde med slutresultatet en færdig artikel til indsendelse!

I dette arbejde skal de studerende læse tekster og formulere fagligt relevante spørgsmål, de skal læse både gode og dårlige artikler og evaluere dem fagligt (hvad er godt, hvad er dårligt) og foreslå forbedringer. Derudover skal de øve sig i problemløsning ved at designe studier og regne på dem, og her vil fokus ikke være på det gennemarbejdede og færdige, men snarere på diskussion og træning i tankegangen. Til slut skal de studerende aflevere autentiske dele (abstract, introduction, methods etc.) af videnskabelige artikler med udgangspunkt i deres eget studie.

Bemærkninger vedrørende praktisk kursusplanlægning

Den færdige kursusbeskrivelse er vedhæftet som Appendix A.

Tidspunktet er valgt, så det passer med den mest optimale feltarbejdsperiode om foråret. Dette passer ikke specielt godt med øvrige relaterede kurser, og det må muligvis overvejes at flytte kurset til efteråret.

Der er i øjeblikket en tendens til konkurrence om de studerende imellem kurserne og ikke mindst institutterne af økonomiske årsager. En væsentlig del af en kommende accept af kurset vil derfor være mere eller mindre uofficielle snakke med lærerne på Biologisk Institut og involvering af disse.

Jeg har sammensat en større lærergruppe. Min erfaring er, at dette giver et spændende læringsmiljø for de studerende, selvom planlægningen typisk bliver mere besværlig og knap så gennemført.

Der kræves i størrelsesorden 20 studerende for at få lov til at køre et kursus. For at undersøge interessen for at deltage i et sådant kursus har jeg spurgt samtlige (71) studerende på kurset "Danmarks fauna – hvirveldyr", hvorvidt de var interesserede i at fortsætte med at beskæftige sig med grupperne, fisk, padder og krybdyr pattedyr og/eller fugle. Den overvejende del af disse svarer positivt på, at de ville vælge et sådant kursus indenfor fugle, hvis det var muligt (den højeste andel for nogle af grupperne).

A Appendix: Kursusbeskrivelse

Course description:

Ornithology

ECTS points:	7.5
Blokstruktur:	4. Blok
Skemagruppe:	
Institutter:	Statens Naturhistoriske Museum og Biologisk Institut
Uddannelsesdel:	Kandidatniveau
Kontaktpersoner:	Kasper Thorup, tlf. 3532 1051, email: kthorup@snm.ku.dk
Andre undervisere:	Knud Andreas Jönsson, Anders Tøttrup, Jon Fjeldså, Carsten Rahbek
Skemaoplysninger:	
Undervisningsperiode:	
Undervisningsform:	Three weekly one-hour lecture and two-hour tutorial and one weekend field excursion. Lectures and tutorials may be combined. The tutorials include: Field excursions (capture and marking, counts; potentially bioacustics or collection of tissue samples), paper discussions with submission of essays, operational exercises (calculus), identification exercises, and preparation of specimens. Throughout the course, the students will work on their own ornithological lab project which will be handed in at the end of the course in the form of a scientific paper.
Formål:	To give the students: • a basic knowledge of ornithology as a basis for continued learning about birds • experience with methods used in ornithological research • ability to evaluate ornithological studies • experience in communicating scientific ornithological studies After the course the students will be well qualified to start Master's Thesis project within ornithology.
Indhold:	Bird biology, including identification and taxonomy, functional morphology, ecology, evolution and behaviour
Målbeskrivelse:	The student will after the course be able to: • Describe all extant bird families and identify most Danish bird species • Explain basic aspects of the ecology, evolution, functional morphology and behaviour of birds • Evaluate scientific ornithological papers • Define ornithological questions and devise solutions • Describe ornithological methods (primarily field based) and apply a selection of these methods • Analyse ornithological data sets • Reflect on the solution to ornithological problems and general inference
Lærebøger:	Gill FB (2007) Ornithology (3rd ed.). WH Freeman.
Tilmelding:	
Faglige forudsætninger:	Knowledge of Danish birds on a level corresponding to the bachelor course Danmarks Fauna – hvirveldyr.
Eksamensform:	Individual oral examination as well as grading of the student's lab project.
Bemærkninger:	At the end of the course, the students must hand in a project in the form of a scientific paper. Several volunteer field trips will be arranged during the course. Undervisningen vil blive afholdt på dansk, hvis alle deltagere taler dansk.
Undervisningssprog:	Engelsk

Tilmelding:	
Faglige forudsætninger:	Knowledge of Danish birds on a level corresponding to the bachelor course Danmarks Fauna – hvirveldyr.
Eksamensform:	Individual oral examination as well as grading of the student's lab project.
Bemærkninger:	At the end of the course, the students must hand in a project in the form of a scientific paper. Several volunteer field trips will be arranged during the course. Undervisningen vil blive afholdt på dansk, hvis alle deltagere taler dansk.
Undervisningssprog:	Engelsk

B Appendix: Gennemgang af kompetencer i forskellige kurser

Obligatoriske kurser - 1. år

Blok	Kursusnavn	ECTS	Original litt	Skrive essays	Opstille hypoteser	Designe studier	Regne-øvelser	Artikel-form
1	Organismernes diversitet - Livets træ	15	%	%	%	%	%	%
2	Matematik/Statistik	7,5	%	%	%	%	%	%
2	Populationsbiologi	7,5	%	%	%	(%)	(%)	(%)
3	Kemi	7,5	%	%	%	%	%	%
3	Almen Økologi	7,5	(Ja)	%	%	%	(%)	Ja
4	Almen Biokemi	7,5	%	%	%	%	(Ja)	%
4	Feltbiologi I, II og III	7,5	%	%	%	%	%	%

Obligatoriske kurser - 2. år

Blok	Kursusnavn	ECTS	Original litt	Skrive essays	Opstille hypoteser	Designe studier	Regne-øvelser	Artikel-form
1	Almen Molekylærbiologi	7,5	%	%	%	%	?	%
1	Almen Cellebiologi	7,5	%	%	%	%	%	%
2	Almen Mikrobiologi	7,5	Ja	Ja	%	%	%	%
2	Menneskets Fysiologi	7,5	%	%	%	%	(%)	%
3	Biologisk Videnskabsteori	7,5	%	%	%	%	%	%
4	Evolutionsbiologi	7,5	%	%	%	%	(%)	%

Valgfrie kurser

Blok	Kursusnavn	ECTS	Original litt	Skrive essays	Opstille hypoteser	Designe studier	Regne-øvelser	Artikel-form
1	Forsøgsplanlægning og eksperimentel metodik i økologi	7,5	%	%	Ja	Ja	Ja	%
1	Biodiversitet	7,5	Ja	Ja	Ja	Ja	Ja	%
2	Eksperimentelt økologisk projektarbejde	7,5	Ja	Ja	Ja	Ja	Ja	Ja
2	Conservation	7,5	Ja	Ja	Ja	Ja	Ja	Ja
3	Introduction to Bioinformatics	7,5	%	%	%	Ja	Ja	%
4	Danmarks fauna - Hvirveldyr	7,5	%	%	%	%	(%)	%
4	Engelsk for B.Sc. naturvidenskabelige studerende	7,5	%	(Ja)	%	%	%	(Ja)

5

Tilrettelæggelse af kursusforløbet på Toksikologi & Økotoksikologi på eliteuddannelsen Miljøkemi og sundhed

Bjarne Styrishave

Institut for Farmaci & Analytisk Kemi, FARMA, Københavns Universitet

Introduktion

Kurset Toksikologi & Økotoksikologi er et obligatorisk kursus på den splinternye eliteuddannelse i Miljøkemi & Sundhed. Uddannelsen er en multifakultetsuddannelse under Det Biovidenskabelige Fakultet på Københavns Universitet, men en række andre institutioner på KU bidrager til uddannelsen. Desuden indgår Rigshospitalet og Danmarks Tekniske Universitet i uddannelsen. Kurset i Toksikologi & Økotoksikologi er det første kursus på uddannelsen og udbydes for første gang i dette efterår 2009. Uddannelsen er en international uddannelse udbudt på engelsk og i 2009 er i alt 16 studerende fordelt på 5 forskellige nationaliteter blevet optaget. Målet med uddannelsen er at optage 20 til 25 studerende om året.

Kurset er placeret i Blok 1 og selve undervisningen er også inddelt i blokke af 4 timers varighed. Der er i alt 24 blokke fordelt over en periode på 8 uger, hvor der ligger en blok på hhv. mandag, tirsdag og fredag. 7 af blokkene er laboratoriearbejde. De resterende 17 blokke består af en blanding af forelæsninger, kollokvium, opgaveregning og øvelser i form af problembaseret læring. Desuden forventes det, at de studerende i perioder med laboratorieforsøg vedligeholder deres forsøg ud over de skemalagte timer. Kurset er således meget intensivt og inkluderer mange undervisningsformer.

Pensum består dels af udvalgte kapitler fra 2 lærebøger, John Timbrell "Principles of Biochemical Toxicology" og Walker et al "Principles of Ecotoxicology" som hver især dækker hhv. toksikologi og økotoksikologi. Desuden understøttes disse af primær litteratur i form af videnskabelige peer-reviewed artikler. Ca. halvdelen af pensum er lærebøger og ca. halvdelen af pensum er peer-reviewed artikler. Intentionen med dette er, at give de studerende en generel og principiel introduktion til et givet emne på en let forståelig måde for derefter at give dem et mere dybdegående indblik i emnet, samt hvorledes disse principper anvendes i praksis af forskere.

Formålet med kurset er beskrevet i fagbeskrivelsen (oversat fra engelsk):

"Formålet med kurset er at introducere de studerende til de fundamentale emner og centrale metoder indenfor humantoksikologi, økotoksikologi og erhvervsrelateret toksikologi samt at give de studerende et overblik over forskellige fremgangsmåder til at producere data der kan anvendes i risikovurdering af kemiske stoffer for mennesker og for miljøet. Kurset består af et antal af forelæsninger og praktiske laboratoriekurser af ca. 20 timers varighed. Kurset anbefales til studerende der efter endte studier vil arbejde indenfor sektorer vedrørende miljø, såsom offentligt tilsyn, befolkningssundhed, miljøkonsulent virksomhed, medicinalindustrien og bioproduktionsindustrien".

Idet der er tale om et helt nyt kursus der ikke er startet endnu, forestår der stadigvæk en del arbejde i at aligne de målsætninger der er beskrevet for kurset med det pensum der rent faktisk undervises i på kurset. Det er ligeledes centralt at det pensum der undervises i og den undervisningsform der anvendes, tillader de studerende at erhverve de kompetencer man ønsker at eksaminere de studerende i. Desuden er det vigtigt at den pågældende eksamensform afspejler undervisningsformen, altså at den valgte eksamensform tillader en reel vurdering af de studerendes opnåede faglighed.

Hvori består ELITE?

I styregruppen for uddannelsen har der været en del diskussion om, hvad der i uddannelsessammenhæng skal lægges i begrebet "elite", altså, hvad betyder det at uddannelsen er en eliteuddannelse og hvorledes adskiller en eliteuddannelse sig fra øvrige uddannelser? Hvilke konsekvenser har dette for undervisningen, for indlæringen og kursusevalueringen, at kurset er et elitekursus? Det elitære element er ikke beskrevet i formålet med kurset (se ovenstående) og er således ikke nærmere defineret og det har derfor i det store hele - indtil videre - været op til de enkelte kursusansvarlige på uddannelsen at definere dette. I kurset Toksikologi & Økotoksikologi er der dog indbygget visse begrænsninger i kursusevalueringen, idet studienævnet i forbindelse med godkendelsen af uddannelsen har vedtaget at mindst 50 % af den endelige karakter for kurset skal gives på baggrund af en individuel multiple choice eksamen, hvorimod de sidste 50 % skal gives i relation til projektorienteret arbejde. For de sidste 50 % har den kursusansvarlige således mulighed for at bestemme evalueringsformen og indholdet indenfor denne ramme. Disse forhold påvirker naturligvis undervisningsformen og dermed også fortolkningen af begrebet "elite".

En multiple choice eksamen er en eksamensform der generelt stimulerer overfladisk læring, idet den begrænser muligheden for at evaluere de studerende i dybden. Dette skyldes, at de studerende ikke får muligheden for at udtrykke sig nuanceret, men blot skal tage stilling for eller imod korte udsagn, ved at markere rigtigt eller forkert med et kryds. Eksaminator har heller ikke mulighed for at stille komplicerede opgaver med mange nuancer, ligesom underviser kun har meget begrænset mulighed for at inddrage videnskabelig litteratur, samt figurer og tabeller i eksamenssættet. Desuden er det sådan, at forkerte svar i den her anvendte multiple choice eksamen tæller negativt, -1, hvorimod et korrekt svar tæller +1, dog kan det samlede antal points i en enkelt opgave bestående af 5 spørgsmål aldrig tilsammen give mindre end 0 points (se eksempel på multiple choice eksamenssopgave i Appendix A). Dette system bevirker således, at der for de studerende er et element at strategi i at besvare spørgsmålene, idet det i visse tilfælde er en fordel ikke at svare på spørgsmålet, hvis man er i tvivl om, hvorvidt svaret ikke er korrekt, hvorved man får et minuspoint. Dette element af strategi har intet med indlæring at gøre.

Hvis der med begrebet "elite" ligger en forventning om, at de studerende på kurset skal erhverve viden eller kompetencer ud over det man finder hos studerende på almindelige kurser, er det yderligere vanskeligt at se, hvorledes multiple choice som eksamensform kan bidrage til dette. Denne eksamensform er dog nedskrevet i studieordningen for kurset og det er således, for indeværende, ikke muligt at ændre på dette. For at sikre et element af elite i kurset og for at sikre at de studerende i nogen grad også bliver evalueret på deres mere dybdegående indlæring er det således afgørende at de sidste 50 % evaluering afspejler dette.

Formål

Formålet med dette projekt er at aligne kursets målbeskrivelse, undervisningsform og evaluering indenfor de rammer der på forhånd er afstukket af studienævnet, herunder at inkorporere et elitært element i denne alignment. Dette gælder en evaluering af de studerendes mere dybdegående forståelse af målbeskrivelserne, samt en evaluering af de studerendes elitære udbytte.

Fremgangsmåde

En mulig fremgangsmåde til at stimulere dybdelæringen hos de studerende i kombination med elitær undervisning kan være at indrette kurset således, at de studerende arbejder i laboratoriet og bearbejder og formidler videnskabelig information på samme måde som forskere gør i deres daglige arbejde. Almindelige kurser på universiteter er typisk indrettet med forelæsninger i kombination med laboratorieøvelser, der er fastlagte på forhånd. En typisk eksamen er en eksamen i form af multiple choice eller assay hvor de studerende bliver eksamineret og får karakterer efter opsatte læringsmål i henhold til et pensum. Begge disse eksamensformer kan betragtes som summative evalueringer, dvs. en bagudrettet evaluering hvor de studerendes opfyldning af de opsatte indlæringsmål testes (Biggs and Tang; 2007). Denne måde at lære på adskiller sig på mange måder fra den måde hvorpå forskere arbejder idet disse selv planlægger laboratoriearbejdet, behandler data og formidler disse enten i form af poster, platform præsentationer eller videnskabelige artikler.

En mulig måde at inkorporere elite og dybdeindlæring på, kunne derfor være at tillade de studerende at arbejde med hele den videnskabelige proces fra planlægning til publicering af de opnåede resultater, som forskere gør i forbindelse med grundforskning.

Opbygning af kurset

For at imødekomme ovenstående blev det besluttet, at den eksperimentelle del af kurset skulle struktureres således at de studerende fra begyndelsen af kurset fik mulighed for at arbejde med hele den videnskabelige procedure, dvs. selv vælge forskningsprojekt, tilrettelægge laboratoriearbejdet, databehandle de opnåede resultater og formidle dette. Laboratoriearbejdet blev inddelt i 2 projekter med 3 blokke i hver (se skema for kurset i Appendix B). Ud fra en liste med abstracts for mulige projekter skulle de studerende selv vælge først ét og senere yderligere ét projekt. Der var et overskud af projekter på listen således at alle hold havde mulighed for at vælge noget de fandt interessant. For at sikre en vis grad af alignment imellem de teoretiske blokke og projekterne blev sidstnævnte baseret på centrale emner fra de teoretiske blokke. Projekterne var således fordelt på alle de deltagende institutioner og varierede i indhold fra analytisk kemi til arbejdsmiljørelaterede dyreforsøg og in vitro forsøg på humane cellelinier. Herefter skulle de studerende selv designe og gennemføre deres forsøg under vejledning og de to projekter skulle afrapporteres hhv. i posterformat og som en videnskabelig artikel.

Foreslået evaluering af de studerende

På baggrund af ovenstående bestemte jeg mig således for, at evalueringen af kurset skulle bestå af 3 segmenter, en multiple choice opgave, som givet på forhånd, der tæller 50 % af den samlede karakter for faget og to videnskabelige rapporter baseret på de to laboratorieprojekter der hver gælder 25 %.

Posterne blev trykt på KU´s trykkeri i A0 format og er således identiske med postere på videnskabelige konferencer. Der blev afholdt en konference sidst på kurset med et format svarende til det man finder på videnskabelige konferencer, dvs. at der var platform præsentationer af det ene projekt, som derefter blev afleveret til bedømmelse i videnskabeligt manuskriptformat. Herefter var der en poster session med kaffe og kage akkurat som på videnskabelige konferencer, hvor de studerende forsvarede deres postere, hvorefter disse ligeledes blev afleveret til bedømmelse. Konferencen blev arrangeret som en offentlig begivenhed, hvor deltagerne bl.a. var lærere og undervisere der har deltaget i kurset, men der deltog også forskere og studerende udefra, således at de studerende på kurset har en realistisk mulighed for at forsvare deres videnskabelige arbejde *ex auditorium*.

Formålet med den ovenfor beskrevne struktur var at give de studerende øvelse i at komme i dybden med et videnskabeligt emne ved at gennemføre hele den videnskabelige proces, hvilket her promoveres ved at sikre at de studerende afrapporterede deres arbejde på samme måde som forskere afrapporterer deres videnskabelige arbejde dvs. ved brug af postere, platform præsentationer og videnskabelige artikler. Dette skulle desuden sikre, at de

50 % af den samlede eksamenskarakter der ikke var baseret på multiple choice, blev baseret på mere dybdebaseret viden og videnskabelig metode hos de studerende opnået gennem en integration af teori, praktisk arbejde samt akademisk refleksion. Konferenceformatet er desuden meget velegnet til at give de studerende formativ evaluering som supplement til den summative evaluering de får i form af en karakter og hele processen må betragtes som værende problembaseret læring.

Kursusevaluering

For at opnå et indblik i de studerendes holdning til kurset og deres eget syn på deres udbytte og for at identificere de elementer af kurset der virkede godt og mindre godt, blev kurset evalueret af de studerende efter konferencen der afsluttede kurset. Der blev gennemført 2 evalueringer, den ene var en obligatorisk skemaevaluering efter et fastlagt skema udarbejdet på KVL som alle kurser på uddannelsen skal evalueres efter. Denne evalueringsform har dog en række ulemper. For eksempel kan de studerende udfylde skemaet udelukkende ved afkrydsning, hvilket de ofte gør, og dette begrænser den kursusansvarliges mulighed for at forstå baggrunden for den pågældende afkrydsning. Som oftest er det også kun en vis andel af de studerende der afleverer skemaerne, hvorfor disse kun er mere eller mindre repræsentative. Af disse årsager blev der parallelt med skemaevalueringen også gennemført en såkaldt delta-evaluering af kurset. Denne evaluering foregår ved at de studerende med deres egne ord nedskriver 3 ting omkring kurset. Dette kan vedrøre alle aspekter af kurset, pensum, lærere, eksamensform, laboratoriearbejde etc. Disse kommentarer sendes så rundt på holdet, hvor hver enkelt studerende blot skal markere hvis de er enige i det pågældende udsagn. Alle udsagnene sendes rundt således at alle studerende får mulighed for at erklære sig enige i alle udsagn. Fordelen ved denne type evaluering er, at den kombinerer kvalitative udsagn med en kvantitativ målestok for hvor mange studerende der deler det synspunkt som udsagnet udtrykker.

På baggrund af de studerendes svar under evalueringen vurderes det, at de to evalueringsformer supplerer hinanden godt. Dette skyldes dels, at de tilsammen giver en dog kombination af kvalitativ og kvantitativ evaluering. Men den væsentlige styrke i denne dobbelte evaluering ligger i kombinationen af præcise spørgsmål stillet af den kursusansvarlige som denne finder relevante og så de personlige synspunkter som de studerende har dannet sig, og som kommer langt bedre til udtryk i delta-evalueringen. I begge evalueringsformer kommer der elementer frem i den ene, som ikke kommer frem i den anden. For eksempel er det indlysende ud fra delta-evalueringen på hvilke punkter kurset skal koordineres med det sideløbende kursus i epidemiologi. Dette er ikke klart ud fra skemaundersøgelsen, her fremgår det kun at en koordinering er påkrævet, ikke på hvilke punkter dette er nødvendigt. Det vil derfor være oplagt også i fremtiden at evaluere kurset ved brug af begge evalueringsformer.

Den fremtidige eksamensform

På baggrund af de erfaringer der er gjort med kurset det første år bør det overvejes om eksamensformen med multiple choice opgaver bør erstattes af en anden type eksamen. Det fremgår tydeligt af kursusevalueringen at det de studerende har størst glæde af og mener at de lærer mest ved er selve den videnskabelige proces hvor man går i dybden med et afgrænset videnskabeligt emne og det er netop disse evner som man forsøger at fremhæve og stimulere på eliteuddannelsen. Det må derfor betragtes som et paradoks, at 50 % af kurset bliver evalueret som multiple choice. Denne eksamensform må formodes at stimulere overfladisk indlæring, idet de studerende på intet tidspunkt under sådan en eksamen skal formulere sig selvstændigt eller forholde sig nuanceret til det faglige stof.

Umiddelbart er der to mulige eksamensformer, som kunne erstatte multiple choice eksamen. Den ene er en mundtlig eksamen, hvis fordel består i, at både eksaminator og den studerende har mulighed for at gå i dybden med relevante emner. Den anden er en skriftlig eksamen baseret på assay besvarelser, hvor eksaminator har mulighed for at stille opgaver af mere kompleks karakter og inddrage videnskabelige data som f.eks. tabeller eller figurer, og hvorigennem den studerende har mulighed for at udtrykke sig nuanceret. Begge disse eksamensformer må anses for mere velegnede til at evaluere de studerendes opfyldelse af formålet med kurset som beskrevet i fagbeskrivelsen, end en multiple choice eksamen. Det er i denne sammenhæng vigtigt at notere sig, at samtlige studerende på kurset erklærer sig enige eller meget enige i, at kursets faglige indhold opfylder læringsmålene (se Appendix C) samt formålet med kurset som beskrevet i fagbeskrivelsen (ifølge skemaevalueringen), mens 80 % af de studerende ifølge delta-evalueringen erklærer sig enige i udsagnet: "Mulitple choice er ikke en særlig elitær eksamensform" (oversat fra engelsk). Dette indikerer et misforhold imellem kursets indhold og den eksamensform der anvendes til at evaluere de studerendes udbytte af dette indhold. Det bør derfor overvejes at anmode studienævnet om tilladelse til at ændre eksamensformen til en anden form for skriftlig eksamen eller en mundtlig eksamen. Dette vil formentlig bidrage til en forbedret alignment imellem på den ene side kursets faglige indhold og på den anden side muligheden for at evaluere de studerendes udbytte af dette indhold.

Konklusion

På baggrund af ovennævnte er der 3 overordnede pointer der bør fremhæves:

1. Det elitære element, hvor de studerende arbejder i dybden med hele den videnskabelige proces fra teori (hypotese om man vil) til afrapportering, er et vigtigt redskab til at stimulere dybdeindlæring.
2. Et bredt indblik i kursets funktionalitet, styrker og svagheder, opnås bedre ved en kombination af de to evalueringsformer (skemaevaluering og delta-evaluering) end ved anvendelse af blot den ene af evalueringsformerne.
3. En bedre alignment af kurset opnås formentlig ved at erstatte multiple choice eksamen med en anden form for eksamen, en skriftlig assay eksamen eller en mundtlig eksamen.

A Appendix: Eksempler på multiple choice eksamensopgaver

The following biomarkers can be considered reliable:

Yes	No	
☐	☐	Egg shell thinning in predatory birds exposed to DDT
☐	☐	Imposex in gastropod snails exposed to tributyltin (TBT)
☐	☐	Nerve signal transmission interruption in mammals exposed to organic mercury
☐	☐	Metallothioneins in molluscs exposed to cadmium
☐	☐	Vitellogenin production in male fish exposed to xeno-estrogens

The model of Concentration Addition

Yes	No	
☐	☐	Theoretically only applies for chemicals with the same mode of action
☐	☐	Can be used to predict the joint effect of an infinite amount of chemicals by first calculating the effect of the single chemicals in the mixture and then adding the effects
☐	☐	Can be used to predict the joint effect of an infinite amount of chemicals by first “exchanging” the chemical concentrations/doses into the same “currency”, then adding them and then calculating the effect from a pre-defined dose-response model
☐	☐	Is the preferred model for risk assessment of mixtures
☐	☐	Can never be used successfully to predict the joint effect of chemicals with different modes of action

B Appendix: Kursusskema

Week	36	37	38	39	40	41	42	43	44
Monday	31-8-09	7-9-09	14-9-09	21-9-09	28-9-09	5-10-09	12-10-09	19-10-09	26-10-09
8-12	Introduction to education	Lab work intro Paper writing	Lab work	Intro to occupational toxicology Organ toxicology	*In vivo* & *in vitro* bioassays	Lab work	Lab work	Reproduction toxicology and teratogenic effects	Conference article + Poster presentation
Teachers	ALL TEACHERS	BST	Group responsible	GDN, SPL	FKN	Group responsible	Group responsible	AMA, KSH	Group responsible
Tuesday	1-9-09	8-9-09	15-9-09	22-9-09	29-9-09	6-10-09	13-10-09	20-10-09	27-10-09
13-17	Principles of toxicology Toxic agents ADME etc.	Lab work	Lab work	Cutaneous toxicology Lung & skin toxicology	Ecotox: Major classes of pollutants	Evolution of resistance to pollution	Lab work	Endocrine disrupting chemicals	Repetition by students
Teachers	BHS	Group responsible	Group responsible	GDN, STL	BST	BST	Group responsible	AMA	
Friday	4-9-09	11-9-09	18-9-09	25-9-09	2-10-09	9-10-09	16-10-09	23-10-09	30-10-09
8-12	Dose-response relationship	Xenobiotic metabolism	*In vivo* & *in vitro* toxicology	Occupational cancer & lung diseases Nanotox	Mechanisms in ecotox Bioconcentration Biomagnification	In situ monitoring Biomarkers in population studies	Population effects, microcosms	Mixture toxicity	EXAM!!!
Teachers	BST	BHS	FKN	ATS, GDN, NRJ	BST	BST	NC	NC	

C Appendix: Course outcome

Upon completion of the course, the student will be able to:

Knowledge:

- Describe toxicological mode of actions for most important groups of chemical substances to humans and environmental species.
- Define the most vulnerable target organ(s) or organism(s) for most important group of xenobiotics.
- Demonstrate knowledge on safety toxicology, and extrapolation from animal to human, and from one trophic level in the environment to another
  - Understand the use of physico-chemical parameters of compounds to predict toxicity, bioaccumulation and biomagnification
  - Assess both acute and chronical toxicity data and evaluate different types of dose-response relationships including effects of mixtures of compounds with similar mode of action.
  - Quantify a dose or an exposure of a chemical and be able to predict the most important exposure routes to humans and environment and exposure due to occupation.
  - Suggest how to diminish an exposure of chemical in human, environmental and occupational toxicology (practical management).
  - Classify chemicals and xenobiotics (Tx, T, Xn, C and Xi).

Skills:

- Transfer math concepts to solve 1st-order linear differential-integral equations, manipulate log relationships, and convert between dimensional systems of units
- Utilise relevant software for dose-responds relationships and problem solving (e.g. EPI-Win, Chem-Draw, Excel, R).
- Perform simple in-vitro human toxicological and ecotoxicological laboratory tests and models
- Report laboratory results as research manuscript

Competencies

- Integrate principles from chemistry, physics, biology, biochemistry and ecology with mass and energy balances to develop and solve simple toxicological questions
- Apply simplified assumptions and estimate model and design parameters in the face of biological variability and uncertainty in measurement and prediction

6

Udvikling af et nyt tværfakultært kursus i biouorganisk kemi

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Introduktion

Dette adjunktpædagogikumprojekt omhandler udviklingen af et nyt kursus i biouorganisk kemi hovedsagligt for studerende på Det Naturvidenskabelige Fakultet (NAT), Det Farmaceutiske Fakultet (FARMA) og Det Biovidenskabelige Fakultet (LIFE) på Københavns Universitet. Underviserne på kurset vil ligeledes være fra fakulteterne NAT, FARMA og LIFE. De første tanker om kurset blev gjort af mine kollegaer i den biouorganiske kemigruppe på Institut for Grundvidenskab og Miljø i efteråret 2007. Jeg overtog ansvaret for planlægningen af kurset i november 2008, og kurset skal efter planen afholdes første gang i 2010, blok 4. Kurset er godkendt af naturvidenskabsstudienævnet på LIFE og registeret i LIFEs kursusdatabase med kursusnummer 230029 (Det Biovidenskabelige Fakultet; 2009a).

Ved at starte et nyt kursus har man mulighed for, uden hensyntagen til gamle traditioner og vaner, at udforme kurset på den bedst mulige måde, hvilket er målet med dette projekt. Da både studerende og undervisere kommer fra forskellige miljøer, som indtil for nylig var 3 separate universiteter, kan der potentielt være udfordringer i, at få kurset til at blive så sammenhængende og givende for de studerende som ønsket.

Mit projekt vil omhandle udviklingen af dette kursus og de overvejelser, der er gjort i processen. Jeg vil inddrage relevant litteratur i forbindelse hermed. Jeg håber desuden, at rapporten vil kunne anvendes som en vejledning til kurset for underviserne og forhåbentligt bidrage til at gøre kurset velstruktureret og sammenhængende med stort udbytte for de studerende.

Når der står "vi" på de følgende sider, menes der underviserne på kurset og hovedsagligt mine kollegaer på LIFE.

Beskrivelse af kursets område

Kurset (230029) udbydes på engelsk og har titlen "The chemistry of metal ions in biological systems". Denne titel dækker over et forskningsområde, som også kaldes biouorganisk kemi eller biologisk uorganisk kemi. Hermed menes kemien for metalioner i biologiske systemer og hovedsagligt metalioner, som er bundet til proteiner og nukleinsyrer. Cirka 1/3 af alle enzymer er afhængige af metalioner for aktivitet, og derudover er metalioner også essentielle i oxygentransport, elektrontransport og fotosyntesen (Det Biovidenskabelige Fakultet; 2009a). Titlen "The chemistry of metal ions in biological systems" er valgt, da jeg tror, den vil have en større salgsværdi end blot biouorganisk kemi. På de følgende sider vil jeg dog bruge benævnelse biouorganisk kemi.

Målgruppe for kurset

Biouorganisk kemi er et tværfagligt forskningsområde, og derfor mener vi også, at kurset vil have interesse for studerende på en række forskellige uddannelser. Fra LIFE mener vi, kurset vil have interesse for studerende fra uddannelserne i Biologi og bioteknologi, Miljøkemi og Levnedsmiddelvidenskab. På NAT vil det have interesse for uddannelserne i Biokemi, Kemi, Nanoteknologi og Molekylær biomedicin, og på FARMA for farmaceutstuderende og studerende på lægemiddelvidenskabsuddannelsen. Kurset kan ligge i periferien for nogle af de nævnte studieretningerne, men vi er overbeviste om, at det vil være relevant for nogle studerende på alle nævnte studieretninger.

Da der forhåbentlig vil komme studerende fra flere af de ovennævnte uddannelser, vil de studerende på kurset komme med forskellige baggrunde og forventninger til kurset. En biokemistuderende vil have meget godt styr på alt med proteiner, mens vedkommende måske har en begrænset viden i uorganisk kemi, og det omvendte vil gælde for en kemistuderende. Underviserne skal derfor være meget opmærksomme på disse forskellige baggrunde og tilrettelægge undervisningen, så alle tilgodeses, så vidt det er muligt. Den valgte lærebog (Bertini et al.; 2007) indeholder en introduktion for "kemikerne" i cellebiologi, biokemi og evolution og en introduktion for "biokemikerne" i koordinationskemi. De studerendes forskellige baggrund kan evt. også udnyttes i forskellige tværfaglige arbejds-/projektgrupper, hvor de studerende kan drage nytte af hinandens fagområder. Dette er noget, der kan forsøges, når underviserne har fået erfaring med kurset, og vi ved mere om hvilke og hvor mange studerende, der kommer fra de forskellige uddannelser.

Oprindeligt var kurset tænkt som et kandidatkursus. De forskellige studieplaner for kandidatuddannelserne viser, at der generelt er afsat 30 ECTS point til valgfrie kurser. Dog er det vanskeligt at forudsige hvor mange kandidatstuderende, der vil vælge kurset. For at sikre at der er et tilstrækkeligt grundlag for kurset, har vi valgt, at kurset også skal kunne tages af bachelorstuderende på deres sidste år. Hvis kurset bliver en stor succes, kan vi efterfølgende gøre det udelukkende til et kandidatkursus.

Valg af blokplacering

Det er indtil videre meningen, at kurset skal afholdes i blok 4. Vi har valgt denne placering, da underviserne på LIFE har en stor undervisningsbelastning i både blok 2 og 3. Blok 1 og 4 var så en mulighed, og ifølge de forskellige studieplaner er blok 4 den, der vil give flest studerende mulighed for at vælge kurset. Efterfølgende er jeg blevet kontaktet af undervisningsrepræsentanten for Foreningen af Bioteknologistuderende på LIFE, som forklarer, at det ikke er muligt for dem at tage kurset hverken på deres sidste år i bacheloruddannelsen eller første år af kandidatuddannelsen. Selvom der i studieplanen for disse studerende står, at de kan tage valgfrie kurser, er her placeret et "kerne"-kursus på 15 ECTS point, som de fleste vælger. Bioteknologistuderende fra LIFE er den gruppe af studerende, vi forventer flest studerende fra, så placeringen i blok 4 er uheldig. Undervisningsrepræsentanten forslår i stedet blok 1, hvor bioteknologistuderende vil have lettere ved at følge kurset. En evt. flytning til blok 1 (2010) vil blive drøftet med de øvrige undervisere.

Pædagogiske principper

Brug af "constructive alignment" i kursusplanlægningen

Begrebet og ideen om "constructive alignment" kommer fra John Biggs (Biggs and Tang; 2007). Ideen med "constructive alignment" er ganske simpelt, at de anvendte undervisnings-/læringsaktiviteter og eksaminationen er nøje afstemt med det, man ønsker de studerende skal lære. Dette lyder som en selvfølgelighed, men ofte er det, de studerende bliver bedømt på ved eksamen, ikke konstruktivt afstemt med det, man faktisk ønsker, at de skal lære. John Biggs har kort opridset fire trin i udformningen af et konstruktivt afstemt kursus (Biggs and Tang; 2007).

- Beskriv det ønskede læringsudbytte og kursusindhold. Specificér konteksten og det niveau de studerende skal nå.
- Skab et læringsmiljø ved brug af undervisnings-/læringsaktiviteter, som stemmer overens med det ønskede læringsudbytte og derfor sandsynligt bibringer det ønskede resultat.
- Anvend samme type opgave til bedømmelsen, som er anvendt som læringsaktiviteter, da disse er afstemt med læringsmålet. Dette gør det muligt at bedømme om og hvor godt, den studerende har lært det ønskede.
- Transformér bedømmelsen til en karakter.

Jeg vil i de følgende afsnit behandle det ønskede læringsudbytte, undervisnings-/læringsaktiviteter og eksamensformen.

Det ønskede læringsudbytte

Udformningen af det ønskede læringsudbytte er meget vigtig, da det skal bruges som rettesnor for planlægningen af undervisningen, og fordi de studerende ved eksamen bliver bedømt i forhold til det ønskede læringsudbytte (Biggs and Tang; 2007, pp. 64–90). Det ønskede læringsudbytte skal beskrives med verber, som afspejler et niveau af kunnen. Dette er nødvendigt, for at den studerende ved, hvilket niveau der forventes, og for at læringsudbyttet kan anvendes i eksamensbedømmelsen. Når det ønskede læringsudbytte udformes, er det også vigtigt at være bevidst om hvilken type af viden, de studerende skal besidde efter kurset. Her skelnes mellem deklarativ viden og funktionel viden. Deklarativ viden kan kort beskrives som viden om ting og funktionel viden som viden om, hvordan man gør ting. Funktionel viden kræver et solidt fundament i deklarativ viden.

Som en hjælp til at beskrive niveauet af den ønskede kunnen kan man anvende enten SOLO-taksonomien (SOLO = Structure of Observed Learning Outcomes) udviklet af Biggs og Collins eller Blooms taksonomi (Biggs and Tang; 2007, pp. 64–90). SOLO-taksonomien inddeler verberne i fire niveauer: unistrukturel, multistrukturel, relationel og udvidet abstrakt. Blooms reviderede taksonomi inddeles i niveauerne: viden, forståelse, anvendelse, analysere, vurdere og kreere. På det Biovidenskabelige Fakultets hjemmeside (Det Biovidenskabelige Fakultet; 2009b) findes en vejledning til udarbejdelse af kursusbeskrivelser med det ønskede læringsudbytte.

Det ønskede læringsudbytte for kurset

Kursusbeskrivelsen med de ønskede læringsudbytter blev først beskrevet på engelsk og er blevet godkendt af Naturvidenskabsstudienævnet på LIFE. Det ønskede læringsudbytte er udarbejdet i samarbejde med kollegaer i den Biouorganiske kemi-gruppe og min pædagogiske vejleder Jan Sølberg. I det følgende præsenterer jeg oversættelsen af det ønskede læringsudbytte.

Det overordnede ønskede læringsudbytte er, at de studerende skal opnå et overblik over metalioners funktion i biologiske systemer. Dette skal gøre dem i stand til at analysere struktur og funktion af biomolekyler indeholdende metalioner.

På det Biovidenskabelige Fakultet skal det ønskede læringsudbytte opdeles i viden, færdigheder og kompetencer. Viden kan sidestilles med deklarativ viden, og færdigheder og kompetencer kan sidestilles med funktionel viden.

Under kategorien ***viden*** ønsker vi, at de studerende er i stand til:

- At beskrive de forskellige funktioner, som metalioner har i biologiske systemer
- At give et overblik over metalloproteiners funktion samt den biologiske udvælgelse af de forskellige metalioner
- At tilegne sig den teoretiske indsigt i spektroskopiske teknikker eller andre metoder der er passende til at undersøge et givent metalloprotein
- At kunne diskutere hvorfor for høje og for lave koncentrationer af sporgrundstoffer er skadelige for levende organismer

Her anvendes verberne beskrive, give et overblik og diskutere, som ligger på det multistrukturelle og relationelle niveau i SOLO-taksonomien.

Under kategorien ***færdigheder*** ønsker vi, at de studerende er i stand til

- At finde og læse primærlitteratur inden for området og kunne forklare indholdet
- At kunne kommunikere klart på skrift og i tale, emner inden for den biouorganiske kemi
- At kunne beskrive funktionen af metalloenzymer på et molekylært niveau

Her anvendes verberne finde, kommunikere og beskrive, som ligger på det multistrukturelle og relationelle niveau i SOLO-taksonomien. Det sidste punkt "at kunne beskrive funktionen ..." kan også være placeret i kategorien viden.

Under kategorien ***kompetencer*** ønsker vi, at de studerende er i stand til

- Kritisk at kunne evaluere data præsenteret i videnskabelige artikler
- Foreslå den potentielle funktion af en given overgangsmetalion i et biologisk molekyle, når der gives strukturel information om metalionens koordination
- Forudsige om en enzymkatalyseret reaktion sandsynligvis er afhængig af en metalion, og hvis ja, hvilken metalion der er sandsynlig.

Her anvendes verberne evaluere, foreslå og forudsige, som ligger på det multistrukturelle og relationelle niveau i SOLO-taksonomien.

Samlet set er der ikke nogen verber på det øverste niveau af hverken SOLO-taksonomien eller Blooms reviderede taksonomi. Biouorganisk kemi vil være et nyt stofområde for de studerende, og de skal lægge en ihærdig indsats for at få det udbytte, som er beskrevet ovenfor. Derfor tror jeg umiddelbart ikke, at det er realistisk, at de studerende vil kunne f.eks. teoretisere eller opstille hypoteser inden for fagområdet. Dette vil selvfølgelig blive genovervejet ved næste revision af kursusbeskrivelsen.

Kursets opbygning

Undervisningen vil blive varetaget af 4 undervisere fra LIFE, 3 fra FARMA og 2 fra NAT, og er fordelt mellem de forskellige undervisere som vist i tabellen nedenfor. Kapitelhenvisningerne refererer til den valgte tekstbog (Bertini et al.; 2007).

Uge	**Emne**	**Undervisere**
1	Introduktion (udvalgte dele af kapitel I-V fra tekstbogen, samt dele af kapitel X ("Long range electron transfer" med fotosystem I + II som eksempel)	KU-LIFE (MJB, MSW)
2	Forslag til emne er: Grundlæggende koordinationskemi (Tutorial II i tekstbog), modelsystemer for metalloproteiner. Kemiske bindinger, ligandfeltteori, Overblik over spektroskopiske teknikker anvendt i biouorganisk kemi, Metalloenzymer med radikal intermediater (kapitel XIII)	KU-NAT (JB, AH)
3	Respiration, oxygens metabolisme (udvalgte dele af kapitel XI og X)	KU-LIFE (MJB, MSW)
4	Hydrogen, nitrogen, karbon og svovl metabolismen (kapitel XII)	KU-LIFE (PWT)
5	Metalioner i sygdomme, sundhed og medicin	KU-FARMA (BG,HRH,STS)
6	Hydrolytisk kemi (kapitel IX og dele af XIV)	KU-LIFE (LHE)
7	Metalionreceptorer og signalering (kapitel XIV og dele af VIII)	KU-LIFE (LHE)
8	Opsamlingsuge for emner, som ikke er blevet dækket tilstrækkeligt i de foregående uger. Rapportskrivning.	
9	Eksamen	Alle

Undervisnings-/læringsaktiviteter

En række forskellige undervisnings-/læringsaktiviteter vil forhåbentligt blive anvendt i kurset. De undervisnings-/læringsaktiviteter, der skal anvendes, bør udvælges på baggrund af det udformede læringsudbytte. Som (Biggs and Tang; 2007) skriver i deres bog, så skal "læringsaktiviteten, der passer bedst til hvert læringsmål findes og anvendes". Tidsrummet, som kan anvendes til undervisnings-/læringsaktiviteterne, er mandage fra kl. 13-17 og onsdage fra kl. 8-17.

Mine tanker omkring aktiviteterne er givet i de følgende afsnit.

	Mandag	Onsdag
Kl. 8-10	-	Læringsaktivitet
Kl. 10-12	-	Læringsaktivitet/ Journal club
Kl. 13-15	Læringsaktivitet	Projektarbejde
Kl. 15-17	Læringsaktivitet/ instrumentpræsentation	Projektarbejde

Forelæsninger

Før man bestemmer sig for en bestemt undervisnings-/læringsaktivitet, bør man tænke over, hvad de studerende gør under aktiviteten. Er de passive? Reflekterer de over informationen? Stemmer deres aktiviteter overens med læringsmålet?

Forelæsninger er en meget anvendt undervisningsaktivitet, hvilket dog ikke er ensbetydende med, at den er bedre end andre undervisnings-/læringsaktiviteter (Gibbs, 1981). Forelæsningen som undervisningsaktivitet stammer tilbage fra tiden før der fandtes trykte bøger. Der er en række grunde til, at vi stadig i dag anvender forelæsninger i stort omfang. En af disse er, at det er en vane eller tradition. Undervisere er selv blevet undervist ved forelæsninger, og det er en form, vi alle kender, og derfor bruger vi den selv (Gibbs; 1981; Mazur; 1997). Et par kendsgerninger der taler imod brug af forelæsning som læringsaktivitet, er:

- Uvejledt læsning er mere effektiv til at præsentere information end forelæsning
- Forelæsning kan ikke forventes at stimulere tankeaktivitet hos de studerende
- Det er sjældent, at en forelæsning inspirerer de studerende
- De studerendes opmærksomhed falder kraftigt efter 10-15 min. forelæsning (Biggs and Tang; 2007, pp. 104-134).

I mange tilfælde vil der være læringsaktiviteter, der er mere velegnede end forelæsningen til at nå den ønskede læring hos de studerende. F.eks. vil en passende læringsaktivitet til læringsmålet “Beskrive de forskellige funktioner metalioner har i biologiske systemer” være, at de studerende i grupper beskriver de forskellige funktioner for hinanden.

For at den studerende lærer noget, skal den studerende selv strukturere sin viden. Forelæseren kan ikke strukturere denne viden for den studerende. Dog kan forelæseren komme med et bud på en strukturering, der kan gøre det lettere for den studerende selv at strukturere den pågældende viden. Forelæsningens styrke i forhold til andre læringsaktiviteter er, at man kan få en eksperts vinkel på og kritiske fortolkning af den viden, der skal læres.

Jeg kan ikke bestemme, hvordan de andre undervisere på kurset skal undervise, men jeg håber, at det er velovervejet, hvis forelæsningen anvendes, og den ikke blot vælges som standard-undervisningsmetode. Hvis forelæsningerne anvendes, håber jeg også, at der skiftes mellem denne læringsaktivitet og flere andre aktiviteter, gerne hver 10.-15. minut, og at forelæsningen holdes så interaktiv som mulig.

Alternativer til forelæsningen

Jeg vil her blot nævne nogle få eksempler på læringsaktiviteter, som kunne anvendes i stedet for forelæsningen. Det drejer sig om forberedelsesopgaver og problembaserede opgaver til gruppedrøftelser.

Ideen med forberedelsesopgaver er, at de skal være lavet af de studerende, inden de møder til undervisning. Dette er noget som bl.a. praktiseres af Eric Mazur (1997) i fysikundervisning på Harvard. Han stiller 3 spørgsmål til det læste stof, som skal besvares og sendes til ham per e-mail aftenen før undervisningen. De studerende skal derudover også svare på, hvad de synes, der var særlig svært at forstå eller forvirrende i teksten. Hvis der ikke var noget, der var svært, skal de svare på, hvad der var mest interessant. For at få adgang til undervisningen næste dag, skal de have svaret på spørgsmålene (Biggs and Tang; 2007, pp. 104–134).

Forskellige problembaserede læringsaktiviteter (PBL) fungerer ofte godt i mindre grupper. På kurset forventes et mindre antal studerende, hvorfor undervisningen vil foregå i et mindre lokale. Dette giver mulighed for, at de studerende kan sætte sig sammen og arbejde i grupper. PBL anvendes ofte til at aktivere de studerende. Denne form giver samtidig mulighed for, at de studerende får diskuteret centrale emner i dagens tekst og får rettet evt. misforståelser hos hinanden. I grupper kan de studerende også undervise hinanden i forskellige dele af pensum. At undervise andre er en meget effektiv måde selv at lære emnet på, da man bliver tvunget til at strukturere sin viden.

Journal club

En læringsaktivitet vi ønsker at bruge er en "journal club". En journal club er et forum, hvor en videnskabelig artikel præsenteres i gruppen og derefter diskuteres. Gennem denne aktivitet får de studerende mulighed for at opfylde følgende læringsmål: At være i stand til at finde og læse primær litteratur inden for området og kunne forklare indholdet samt kritisk at kunne evaluere data præsenteret i videnskabelige artikler. Artiklerne, som bruges til journal klubben, udvælges af underviseren. Én studerende får ansvaret for at præsentere artiklen, mens to eller tre studerende får rollen som hovedopponenter. Det vil sige, at de skal have forberedt en række spørgsmål til artiklen. De øvrige studerende forventes også at have læst artiklen grundigt og bidrage med spørgsmål og diskussion. Herved gøres de studerende til aktive deltagere i undervisningen.

Instrumentpræsentation

En del af underviserne har forskelligt avanceret apparatur, som anvendes i deres forskning. Jeg håber, det vil være muligt at tage de studerende med rundt til nogle af de forskellige laboratorier og få en demonstration af disse forskellige måleinstrumenter. Dette gør det forhåbentligt lidt lettere for de studerende at forholde sig til nogle af de teoretisk vanskellige teknikker, der anvendes i biouorganisk kemi. Samtidig er det også en måde for underviserne at gøre reklame for forskningen i deres grupper. For at disse instrumentpræsentationer er mulige, skal undervisningen fordeles mellem hhv. Frederiksberg Campus og Nørre Campus. Det vil også være naturligt, at undervisningen på et tværfakultært kursus ikke kun foregår på det ene fakultet.

Projektarbejde

En del af kurset vil bestå af projektarbejde. Dette er en problembaseret læringsaktivitet, som ofte engagerer de studerende i høj grad. Projektarbejdet er valgt, fordi denne type undervisning adresserer en række ønskede læringsmål, bl.a. at være i stand til at finde og læse primærlitteratur inden for området, kunne forklare indholdet af det læste og kunne kommunikere klart, både på skrift og i tale, emner inden for den biouorganiske kemi.

Projektarbejdet skal føre til en rapport, der af form ligner en oversigtsartikel. Selve rapporten skal desuden indgå som en del af den afsluttende bedømmelse. Vi har valgt, at projektarbejdet skal være individuelt. Dette har vi valgt, fordi vi derved undgår problemer med individuel eksamination i noget, som er produceret i en gruppe. Vi undgår også problemer med konflikter og samarbejdsproblemer, der kunne forekomme i en gruppe. Som underviser kan det være vanskelligt at løse konflikter i grupperne, og disse konflikter vil kunne være meget skadelige for den præstation, som bliver leveret i eksaminationen. Samarbejdsproblemer i grupper er særligt følsomme i blokstrukturen, da blot få ugers ineffektivitet er en stor del af den tilgængelige tid.

Inden kursusstart vil der blive fremstillet et projektkatalog med emnerne, der vælges imellem. Hver underviser bidrager med mindst et projekt og skal fungere som vejleder på projektet. Emnerne vil typisk ligge inden for de forskellige underviseres ekspertområde, og underviseren skal derfor ikke sætte sig ind i et nyt fagområde. Hvis enkelte studerende har helt specielle ønsker om et projektemne, og en underviser på kurset vil varetage vejledningen, skal dette selvfølgelig også være muligt. Hvis flere studerende ønsker at skrive om samme projekt, skal dette være muligt. Dog er det så et krav, at de studerende vælger forskellige vinkler på projektet. I det tilfælde hvor flere studerende har valgt samme emne, kan de med fordel danne en studiegruppe, hvor de kan udveksle viden om emnet. Dette vil være til nytte for dem, selvom de har forskellige vinkler på projektet. For at undgå overbelastning af den enkelte underviser, skal denne kunne sætte et loft på hvor mange studerende, der kan vælge dennes projekt.

Da rapporten er en del af eksaminationen, skal kravene til denne være helt klart defineret fra starten, så der ikke senere kan opstå klagesager.

Arbejdsbelastningen for projektarbejdet skal svare til 2,5 ECTS point. Rapportens længde forventes at være 10-15 sider udover forside, referencer og evt. bilag. Rapporten skal afleveres senest i den sidste undervisningsuge.

Eksamination

Den afsluttende bedømmelse vægtes med 50 % for rapporten og med 50 % for den mundtlige præsentation af rapporten og efterfølgende diskussion. Eksaminationen vil blive udført med ekstern censur og vejleder som eksaminator. Herudover vil der være mulighed for, at den kursusansvarlige kan deltage. Der gives karakter efter 7-trins skalaen. Vi overvejede at anvende bestået/ikke bestået, men dette vil ofte føre til, at de studerende vil nedprioritere kurset, især hvis der gives karakterer i det andet kursus, de har.

Eksaminationen vil bestå af 15 min. præsentation, 10 min. spørgsmål og diskussion, og 5 min. votering. Der kan herved eksamineres 2 studerende i timen. Hvis kurset bliver populært, vil det føre til et betydeligt eksaminationsarbejde, og det kan blive nødvendigt at genoverveje tidsforbruget.

Et potentielt problem ved projektarbejde og en eksamination udelukkende baseret på rapporten og den mundtlige præsentation/diskussion af denne er, at de studerende ikke bliver eksamineret i hele det læste pensum. Dette kan føre til, at nogle studerende vælger kun at deltage i projektarbejdet og udebliver fra de andre læringsaktiviteter. Derfor har vi besluttet, at der under eksaminationen bør stilles spørgsmål til den studerende, som relaterer projektet til det læste pensum. Eksempelvis hvordan det givne enzym adskiller sig fra et andet enzym, som der er undervist i. For at den studerende kan kvalificere sig til eksamen, skal der udover en afleveret rapport også være leveret en præsentation af en videnskabelig artikel, samt gives kritik på en artikel, jf. Journal Club.

Afsluttende kommentarer

Endnu ikke afklarede emner

Fordelingen af studenterårsværk (STÅ) på kurset har været et diskussionsemne i forbindelse med planlægningen af kurset. Dette problem skulle dog være løst per 1/9-09, hvor en automatisk fordelingsmodel for STÅ imellem fakulteterne skulle være på plads (iflg. prodekan for undervisning på LIFE).

En anden besværlighed er, at der endnu ikke eksisterer en fælles kursusdatabase for Københavns Universitet. Det besværliggør synliggørelsen af kurset for studerende på FARMA og NAT, da kurset indtil videre kun står i kursusdatabasen på LIFE. Det har endnu ikke været muligt at få kurset vist i kursusdatabaserne på NAT og FARMA. En fælles kursusdatabase er under udvikling og er forhåbentlig snart klar. I øjeblikket skal studerende fra NAT og FARMA tilmelde sig kurset på samme måde som gæstestuderende fra andre universiteter. En vejledning til dette findes på http://www.life.ku.dk/uddannelse/enkeltfag.aspx.

Der skal indsendes et ansøgningsskema til LIFE, og der skal indhentes en forhåndsgodkendelse fra den studerendes fakultet. På NAT har en af underviserne spurgt studieadministration, om der kan ligge en permanent forhåndsgodkendelse af kurset fra NATs side, så de studerende automatisk får forhåndsgodkendelsen. Jeg afventer stadig svar på dette. Tilmeldingen og synliggørelsen på NAT og FARMA bliver forhåbentligt lettere, når den nye kursusdatabase tages i brug.

Det videre forløb indtil kursusstart

Der er stadig mange detaljer omkring kurset, som skal på plads inden kursusstart. Herunder skal der laves en mere detaljeret kursusplan med pensumliste, og der skal udarbejdes et projektkatalog. Jeg vil også forsøge at arrangere et møde i løbet af efteråret 2009 for underviserne, hvor vi kan diskutere kurset igennem og få afklaret eventuelle spørgsmål. Underviserne på kurset har alle større undervisningserfaring end jeg, og jeg håber, de vil påpege uhensigtsmæssige elementer i kurset og bidrage med gode ideer.

Da kurset er nystartet, skal der gøres en ekstra indsats for at reklamere for kurset på de forskellige uddannelser. Der bør bl.a. laves reklameplakater, som hænges op på de steder, hvor de potentielle studerende færdes. Desuden vil jeg forsøge at få lavet en hjemmeside om kurset, der er mere indbydende end den officielle kursusbeskrivelse.

Til slut vil jeg gerne takke underviserne på kurset for diskussioner og ideer til kurset. Jeg ser frem til kursusstarten, hvor vi sammen kan søsætte et nyt og spændende kursus som i mange år har manglet på Københavns Universitet.

Note tilføjet 1/11-09.
Angående STÅ fordeling mellem fakulteterne kommer der ikke en automatisk fordeling. Der skal i stedet indgås en kursusspecifik aftale mellem underviserne omkring fordeling af STÅ.
Efter konstruktive kommentarer på denne rapport og diskussion med undervisere på kurset har vi bestemt, at projektopgaven skal laves som et gruppeprojekt. Jeg forsøger i øjeblikket at få ændret dette punkt i kursusbeskrivelsen.

Del II

Evaluating and Revising Existing Courses

7

Student motivation and activation by research-based laboratory exercises

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Introduction

Laboratory exercises are an integral part of the undergraduate bioscience curriculum and typically represent the “hands-on” component of lecture-based courses. It is widely believed that the laboratory provides the learning forum where theory and practice merge and where students acquire practical techniques and skills for future employments in the bioscience-related field. However, recent studies revealed that there is in fact a large discrepancy, both among and between students and teachers, in the perception of the exact function of the laboratory component and its correlation to the lecture part of the course content (Russel and Weaver; 2008, and references therein). Traditional laboratory design is often based on written manual instructions where the students’ explicit goal is to follow exactly the procedures and to complete the experiment. Thus, success in the laboratory is, from this perspective, solely based on getting the pre-determined answer from the experiments, and not to learn the theory behind the practice of the laboratory settings. This contrasts greatly with the expressed purpose for the laboratory from the science education point of view, which includes, in addition to the practical skills, an understanding of scientific concepts, interest and motivation, and problem solving capabilities (Hofstein and Lunetta; 2004; Hofstein and Mamlok-Naaman; 2007; Russel and Weaver; 2008). Efforts to accomplish these goals include laboratory teaching approaches that are “inquiry-based”. This broad term commonly refers to the engagement of students in research-driven activities which can be implemented at various levels (Rehorek; 2004; Howard and Miskovski; 2005;

Cunningham et al.; 2006; Weaver et al.; 2008). Consistently, Weaver et al. (2008) proposed that inquiry-based approaches occur on a continuum, ranging from some being very guided by the instructor to others being very open-ended with high student autonomy and responsibility (Figure 7.1).

Fig. 7.1. Model illustrating that incorporation of inquiry and research in laboratory classes exists on a continuum with different degree of student responsibility. Reproduced from (Weaver et al.; 2008).

A major aspect of the inquiry-based approaches is to create an environment where the students participate in the generation of new knowledge and contribute to a larger research effort. Thereby, the students' focus is directed away from the pre-determined outcomes of the traditional laboratory exercises towards the scientific processes of discovery. These include the formulation of scientific questions, making observations, collecting and analyzing data, revisiting experimental settings due to failure, and communication of the results. Several studies have confirmed that students benefit from these research activities and that integrating authentic research in teaching is a way to improve students' learning and motivation (Jenkins et al.; 2003; Howard and Miskovski; 2005; Russel and Weaver; 2008).

Revision of traditional laboratory classes towards inquiry- and research-driven activities follow experiences from successful efforts to incorporate active learning pedagogies in traditional lecture-based courses. Research provided strong evidence that students learn more if they "*read, write, discuss, or be engaged in solving problems... than just listen*" (Bonwell and Eison; 1991). Based on these findings, several teaching/learning activities (TLAs) were developed that range from group discussion, interactive and peer-teaching, to collaborative and problem-based learning (Biggs and Tang; 2007). Common to all these approaches is the attempt to create a learning atmosphere that increases students' interest and engagement in the activity or problem-solving task itself and hence, to enhance their "intrinsic" motivation as driving force for deep learning (Biggs and Tang; 2007).

Problem definition and objectives

The course "Plant Molecular Biology" is part of the bachelor program at the University of Copenhagen and open to students of various disciplines including Biology, Biochemistry and Biomedicine. The course is given in block structure over a period of two months and consists of 3 h of lecture and a full day of laboratory each week. Lectures cover textbook knowledge as well as student seminars related to various topics in plant growth and development, hormone signalling, genome organisation and gene regulation, environmental stress and plant disease. The laboratory deals with the theoretical background and application of basic methods and techniques in molecular biology and genetics and is divided into different labs that continue over several weeks. Thus, students need to handle several rather independent assignments with different instructors at the same day. Being an instructor on different course sections over the last years, I often had the impression that students methodically followed the protocols but had difficulties to grasp the theoretical backgrounds and adapt to the various independent experiments during a course day. This structure resulted frequently in high level confusion during the practical part and a lack of active participation during the theoretical introductions to the different labs. Therefore, I sought to overhaul the laboratory, being aware that changes on the part under my responsibility had to be applied "isolated" within the context of the other labs and lecture classes which were kept unchanged compared to previous years. In revising the lab, my objectives were as follows:

- Increase students' motivation and engagement in the lab
- Expose students to a real-life lab situation and scientific processes of discovery
- Let students participate in a larger research effort
- Help students to see the "big picture" and make connections between concepts
- Enhance students' ability to communicate their results
- Relate the lecture to research-driven contents of the lab

Methods

Research-driven problem and lab manual

The laboratory part "Cloning" is distributed over 7 course days once a week and based on a lab manual entitled "construction of epitope-tagged proteins for interaction". The lab has been running since 2003 with a constant number of students (12-14, typically organized in teams of two students) in a nearly unchanged manner under the responsibility of different instructors. I was the main instructor in the past two years (2007-2008) and used the inherited lab manual with only a few formal changes. I already felt in these years, that the manual was outdated because the exemplary constructs that were cloned for interaction studies had been used some years before in the lab without any success. Thus, student classes were repeating over several years cloning work that was known to be of no further relevance, only as cloning example *per se*. Therefore, the major task was to change the artificial and outdated lab manual towards an authentic research effort that is part of an ongoing research project in the lab. In addition, changes were made under the pragmatic consideration that the manual could be easily adjusted in the next years according to the future project status. However, since the overall structure and subjects of the course did not change, the research task within the cloning lab had to be closely aligned with the previously defined intended learning objectives (ILOs) of the course (see Appendix A).

The research task of the modified "cloning lab 2009" arose from one of the major projects in our lab dealing with the "regulation and execution of cell death in plant innate immunity". We have recently shown that programmed cell death (PCD) associated with a pathogen-triggered defence reaction (hypersensitive response, HR), engages an ancient vesicular pathway for degradation of cellular contents, termed autophagy (greek for "self-eating") (Hofius et al.; 2009). Efforts to identify regulators of this PCD reaction suggested that two proteins, ACCELERATED CELL DEATH 11 (ACD11) and its closest homolog (ACDH1), could be directly or indirectly linked to autophagy via protein interactions with essential autophagy effector proteins (ATGs). To verify this hypothesis, protein-protein interactions need to be demonstrated *in vivo*, which is commonly addressed by co-immunoprecipitation of the candidate proteins. Thus, the modified lab dealt with cloning of epitope-tagged proteins for *in planta* verification of ACD11-related protein complexes. To emphasize that the task would help to solve a genuine research problem, the 12 students were not only divided into lab teams of two students but also in two major groups (teams #1-3 and #4-6) that would contribute to the overall research project by cloning in a complementary manner two constructs (ACDH1 and ATGx) with different epitopes for the co-immunoprecipitation assay. The integration of these research-driven aspects into the lab was accommodated by providing a thorough introduction into the background of our research project in the lab manual. Furthermore, it was important to make the students aware that cloning of these constructs has not been done before. Thus, it was highlighted in the manual that the protocol should only be regarded as guideline and adjustments are likely to occur according to the progress and/or problems during the course.

Teaching/learning activities

An essential component of the attempt to create a motivating and authentic research environment was the integration of different teaching/learning activities (TLAs) into the introductory lectures to each lab day. Based on experiences from previous years, special emphasis was placed on incorporating questions, both convergent and divergent (Biggs and Tang; 2007), as well as group work to increase students' participation during the lecture. With respect to the introduction of the research-based aspects of the laboratory, the prelab lecture of the first day was of great importance and was meant to present to the students the "bigger picture" and conceptual context that the research task is part of. Most TLAs during the relatively short (15-30 min) introductions to the following lab days concentrated on recapitulating the previous lab day(s) including the status of the cloning, technical problems and respective solutions that were discussed and developed in the class. Short group assignments (2-4 people) were combined with individual questions and the whiteboard was typically used to collect the answers (either by students or instructor) prior to the class discussion. Both powerpoint slides and the whiteboard were used to outline the ILOs of each lab day, to illustrate the theory behind the different methods (e.g. PCR, restriction, ligation, transformation, plasmid purification), to show the different results of the various cloning steps (e.g. DNA gel pictures), and to indicate the overall procedures (with emphasis on the modifications compared to the lab manual) for each lab day.

Lab report assignment

One important approach to increase the student ownership and engagement in the research-driven lab exercise was the team assignment to present their results in a "real-life" lab report. The rationale behind this written format was communicated as follows; (1) that research with gene-modified organisms generally requires proper documentation, (2) that cloning details and sequences of each construct need to be documented to allow further use in the research project, and (3) that there is a specific scientific way how research is transmitted to the community, which usually requires practical training. Therefore, students were asked to write the lab report in the form of a scientific paper, including Summary, Introduction, Materials and Methods, Results and Discussion. During most of the lab days, the recapitulation of the methods and results from the previous week(s) were presented in relation to the assignment, which was typically highlighted by one ILO at the respective course day. Furthermore, the final analysis and sum-up of the course was closely aligned with the lab report task. Lab reports were asked to be completed one week after the last course day and the teams received general comments at the Q & A session in preparation of the exam as well as individual corrections and comments in electronic form. However, it is important to note that lab reports as such were not part of the final exam.

Constructive alignment of lecture and lab content

Since I had the opportunity to give the disease lecture of the PMB course as part of my teaching evaluation, the content of the inherited lecture was modified to constructively align the ILOs of the lecture and laboratory part. Hence, the disease lecture aimed to broaden the introduction into the multilayered nature of the plant innate immune system and to elaborate on specific issues related to the research-driven lab content. This included the concepts of programmed cell death, autophagy and multi-protein complexes in pathogen-triggered defence responses.

Course evaluation

In order to evaluate the acceptance and usefulness of the research-driven aspects of the lab content as well as the lab report assignment and different

TLAs, a questionnaire with 14 questions were handed out to the students at the end of the course (Appendix C). Questions 1-13 were designed in multiple choice style with 5 categories (“excellent, very good, reasonable, bad, terrible” or “very much, much, reasonable, not much, very little”) and followed by an empty field for comments and suggestions for improvements. To simplify the interpretation and presentation of the results, answers in categories 1 and 2 (“excellent, very good” or “very much, much”), as well as 4 and 5 (“bad, terrible” or “not much, very little”) were fused and designated as “positive” and “negative”, respectively. Category 3 (“reasonable”) was assumed to be “indecisive/neutral” towards the issue addressed in the questions. In general, the number of questions was kept to a minimum since the questionnaire was a supplement to the overall course evaluation form handed out by the course leader every year.

Results and Discussion

Revision of “cloning lab” towards research-driven activities

Since the overall structure and content of the different lecture classes and labs were not subjected to any major changes, the “real-life” research task implemented into the “cloning lab” was fitted into the context of the intended learning outcomes (ILO3, ILO8, ILO10 and ILO11) of the PMB course (Appendix A). Accordingly, the objectives of the cloning lab were outlined in the modified manual and/or the introductory lecture as follows:

- *To define the principles behind PCR, cloning and sequencing*
- *To evaluate the use of different epitope tags for protein complex analysis*
- *To use databases and bioinformatics tools to select candidates for protein interactions*
- *Acquire knowledge on the role of protein complexes and networks in plant immunity*
- *To design strategies for protein complex analysis using co-immunoprecipitation*

Based on these ILOs, students were involved in an ongoing research effort dealing with the analysis of protein networks in the regulation of plant immunity and cell death pathways. More specifically, the students were asked to “help” with the cloning of two epitope-tagged constructs to facilitate the *in planta* analysis of the potential interaction between two candidate proteins, ACDH1 and ATGx, by co-immunoprecipitation. In order to increase the value of the students' contribution to the project, the 6 student teams were divided into two major groups, so that both constructs could be cloned in parallel during the lab. The lab manual provided all necessary protocols for the different cloning steps (PCR amplification, DNA digestion and purification, ligations and transformation in *E. coli*, colony-PCR, plasmid isolation, sequencing reactions) as well as the gene-specific details (DNA sequence, restrictions sites, plant expression vectors) for both constructs. To give the students more ownership of their cloning tasks, the relevance and importance of the laboratory for the overall project and thus, for the generation of new knowledge, was illustrated as flowchart in the lab manual introduction (Appendix B). It was important to emphasize to the students that the lab manual was meant to serve as "handbook" and "guideline" for the different methods rather than being an "authority" that they should follow without further thinking (Russel and Weaver; 2008). Accordingly, various adjustments were made to the protocols during the progression of cloning, which corresponds to a real-life lab situation. In summary, the revision on the laboratory content could be described as research-driven "guided-inquiry" (Figure 7.1) where the "*instructor still plays a pivotal role in providing both the questions to be asked and the means to obtain and evaluate the answers*" (Howard and Miskovski; 2005). Nevertheless, students' perception of the quality and usefulness of the cloning lab manual appeared to be heterogeneous, since a relatively high proportion (45%) of the students were indecisive compared to the students that had a positive impression (55%) (Appendix C, Q3). This could indicate that some students kept indeed a traditional attitude toward the "authority" of the lab manual so that modifications during the lab would simply appear as mistakes in the manual and not as "real life" adjustments.

Cloning results and lab reports

Overall, the cloning efforts of 6 teams (12 students) resulted in successful generation of one construct (pCAMBIA1300-Myc:ATGx), which contained the inserted gene with the correct sequence and orientation (non-directional cloning using a single restriction site can cause two alternative ways of insertion into the vector plasmid). The two other teams from this group were able to identify potentially positive, plasmid containing *E.coli* colonies by colony-PCR. However, subsequent sequencing of the isolated plasmids revealed only empty vector plasmids, which could be due to incorrect labelling during colony-PCR and/or plasmid isolation. One team involved in the cloning of the second construct (pCAMBIA3300-HA:ACDH1) generated a plasmid with the correct insertion but wrong orientation, whereas the two other teams were only able to identify empty plasmids. Therefore, the cloning approach was only partially successful in terms of progress in our research project. However, the variability in the results and success rates of the different teams provided the "perfect" platform to teach "troubleshooting" skills and to incorporate scientific reasoning, critical thinking and collaborative problem solving into class discussions, in particular at the summing up part of the final lab day. In addition, the students were forced to wrestle with imperfect data during the preparation of the lab reports. This assignment generally aimed at enhancing the students' ability to communicate scientific results, which was indicated by expanding the before mentioned ILOs in the introductory lecture as follows:

- To acquire knowledge on writing research reports and documentation of laboratory work

In agreement with this objective, parts of the introductory and recapitulating lectures to the various lab days were dedicated to the way of presenting the scientific background, protocols and results in the lab report. Five teams delivered the lab report at the requested deadline. One team had apparently difficulties in finishing the report because one team member quitted the course a few weeks before the end and the remaining student never sent the document, although promised. The obtained reports gave the overall impression that most of the students had little experience in presenting their results in the requested scientific format of Summary, Introduction, Materials and Methods, Results and Discussion. Instead, some students showed the tendency to stick to the manual and/or uploaded power point slides and simply rephrased or copied parts of the introduction and protocols for their reports. Others reduced the Introduction and Discussion to a minimum and concentrated only on the presentation of their results in form of gel pictures. However, one group apparently put much effort into the assignment and produced a very good lab report in the requested research paper style including even an Abstract! Also, they succeeded in writing a Materials and Methods section where they got rid of the structured daily format of the manual. Interestingly, these students didn't appear to have much practical experience in the lab, but they showed a lot of interest into the subject and were finally the only ones that succeeded with their cloning task. These obvious differences in the students' attitude towards the preparation of the lab report were also reflected by the answers to the respective questions in the questionnaire. A noticeable number of students stated that the lab report assignment improved their learning motivation only "reasonably" (27%) or "not much" (18%) (Appendix C, Q12). Consistently, 27% of the students did not learn "much" from the lab report and additional 27% felt only a "reasonable" effect on their learning outcome (Q13). Nevertheless, a slight majority of the students (55%) still had a positive feeling towards the lab report assignment for their learning motivation.

Student motivation and engagement

One of the major objectives for the revision of laboratory and lecture contents was to enhance the students' engagement and motivation during the course, which is the prerequisite for deeper learning (Biggs and Tang; 2007). An essential supplement to the research-driven activities was the incorporation of suitable TLAs to increase students' active participation during the lectures. Conceptual questions raised during the introductory lecture to the lab as well during the disease lecture were typically followed by short team (2 students) or group discussions (4 students) and subsequent presentation of the group answers by a "spokesman". This method also proved to be increasingly important during the recapitulating sessions in the beginning of each lab day, since the two best performing students (males) tended to dominate the class when convergent questions were expected to be answered by individuals. In particular, the majority of the female students (9 females vs. 3 males) seemed to be hampered from active participation, and the group discussion format significantly helped to avoid this situation. Nevertheless, a big portion of the students (72%) stated that questions during lecture and exercises were generally helpful to increase their active participation (Appendix C, Q10). Similarly, the group work during the introductory lecture of the cloning lab gave a positive impression to the vast majority of the students (82% vs. 18% "indecisive", Q2), whereas the group activities to recapitulate the contents of the previous course were only positively acknowledged by half (50%) of the students (compared to 50% "indecisive" students, Q6). This result, however, did not influence the overall perception of the general course introduction vs. the introductions to the different course days, since a positive impression was shared by the great majority of students in both cases (77% and 73%, respectively; Q1&4). Nevertheless, the attempt to emphasize the ILOs at the beginning of each course proved to be less successful, since a higher ratio of the students (55%) was indifferent towards the quality and/or usefulness of their presentation (Q5).

In terms of students' motivation and engagement, the evaluation revealed a positive learning environment during the cloning lab (64% positive vs. 36% indecisive, Q8), which was noticeably better than the overall motivation during the other lab exercises (45% positive vs. 55% indecisive, Q9). One reason for this notion could indeed be found in the implementation of research-driven activities. ˜72% of the students stated that participation in a research-based exercise with uncertain outcome (open-end) improved their learning motivation (Q11), which was one of the major goals of this project. However, as mentioned before, the motivating effect of the lab report assignment was less pronounced. Two answers to the empty field question (Q14) could give an indication for the different perception of the lab report assignment. One student wrote that "*I have done a lot of reports, the outcome of that part was limited, but for people with no such experience it is a very good exercise*" ... whereas the other one said that it "*would be better if we're encouraged to write and hand-in lab reports after each day.*" Therefore, it appeared that the students had a very traditional attitude towards the lab report, which was simply regarded as protocol of the lab work as done in traditional verification laboratories. Thus, the lab report assignment was apparently not perceived as important part of the research-driven curriculum in order to practice and improve the scientific communication skills.

Conclusions

The results of this project gave the strong impression that incorporation of research-driven activities into "traditional" laboratory classes, even on a low level of student responsibility (Weaver et al.; 2008), can help to increase students' motivation and engagement. Students seemed to acknowledge the uncertain, "open-ended" nature of the laboratory settings and appeared to be stimulated by participating in an authentic research effort. In this respect, it was essential to take various opportunities during the introductory lab and disease lecture(s) to align the laboratory task with the overall research context and to make connections between the underlying concepts of innate immunity, cell death pathways and regulatory protein networks.

Accordingly, the assignment to write the lab report in a scientific format also aimed at forcing the students to elaborate on scientific background and hypotheses of the research project. However, the varying quality of the reports received indicated that considerably more time is needed to instruct and guide the inexperienced students towards “research-based” lab reports in an appropriate format. Students’ perception of the lab report still seems to originate from the traditional laboratory design, where the answers of the “verification” labs have to be communicated to the instructor to complete the assignments. In this context, training of scientific communication and critical thinking skills are not the primary focus of the reports as it is intended in a research-driven laboratory curriculum. Therefore, future attempts to incorporate scientific lab report formats into the laboratory should aim at including the report assignment into the course assessment.

The TLAs integrated into the lectures helped pretty well to increase the interaction with the students and to create an overall atmosphere of student engagement and motivation. On this basis, the spectrum of TLAs can now be further expanded, for instance with ultra-short essays at the beginning and end of the class. The students are asked to respond to short questions regarding the lecture/lab content which should (1) help the teacher to quickly detect progress and problems of teaching and learning, and (2) force the students to do the pre-reading of the lab manual (one-/three-minute essays, Biggs and Tang (2007)). The experiences from this year confirmed my impression, that the lack of preparedness of students in the laboratory classes with changing labs and instructors is one of the main issues to be addressed in the future.

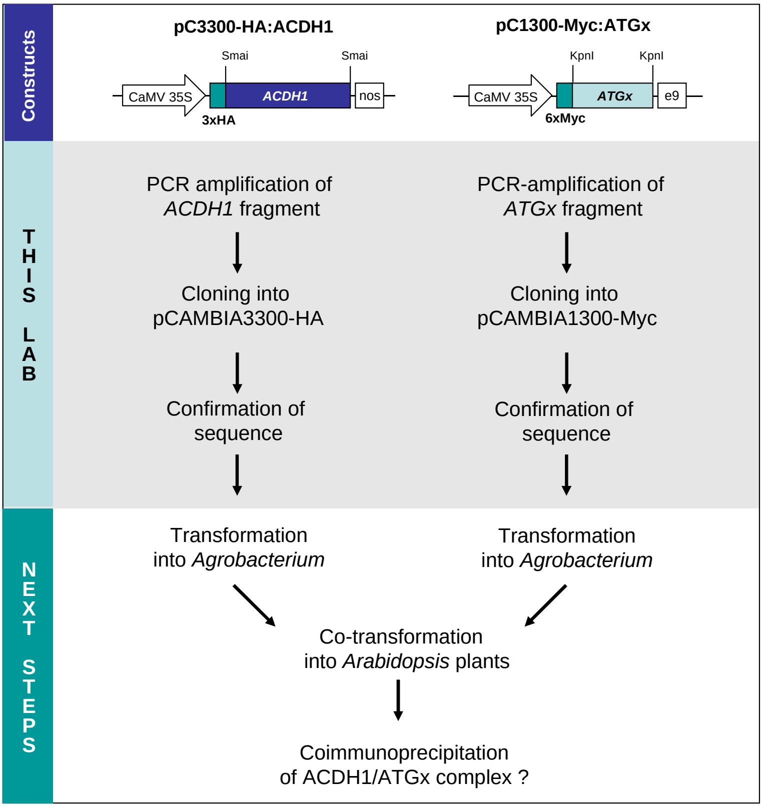
As mentioned, the research-based activities were implemented on a relatively low inquiry-level since the context of the other labs and lectures were not subjected to any major changes. Future revision on this course should be an overall effort, which provides the possibility to incorporate a spectrum of methods and activities and thus to progress towards more open-ended inquiry projects. These should be of great benefit both for students and teachers/researchers (Howard and Miskovski; 2005).

A Appendix: Intended learning outcomes (ILOs) translated from the PMB course description

1. Explain the plant Arabidopsis development and anatomy
2. Identify phenotypic mutants
3. Describe plant-pathogen interactions
4. Explain the effect of plant hormones jasmonate, salicylic acid, auxin and gibberellin
5. Perform epistatic analysis
6. Explain the forward and reverse genetic screens
7. Gain knowledge of other plant-model organisms
8. Use bioinformatics for simple purposes, such as that for annotating genes, get ideas on protein function, suggest protein complexes (Rosetta Stone) and find mutants
9. Interpret the type of examples of experimental data is introduced at the course
10. Suggest attempt to answer the scientific question
11. Define the principles behind cloning, PCR, sequencing, real-time PCR, mutagenesis, epitope tagged proteins, reporter genes, marker genes, transposable-tagging, plant transformation and selection

B Appendix: Final constructs and flow chart of the "cloning" lab

Final constructs and flow chart of the "cloning" lab as well as next steps to perform co-immunoprecipitation of the putative ACDH1/ATGx complex in plants.



C Appendix: Results of questionnaire

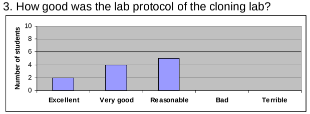
Results of questionnaire (13 questions in multiple choice style and 1 open field question).

1. How was the introducing lecture (Day 1) to the cloning lab?

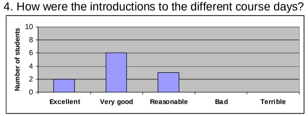
(2 students didn't answer)

2. What do you think about the group work during the introducing lecture?

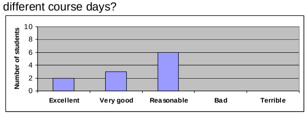
3. How good was the lab protocol of the cloning lab?



4. How were the introductions to the different course days?



5. How good was the presentation of the learning objectives for the different course days?

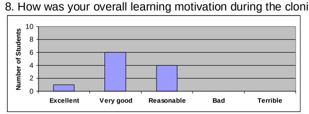


6. What do you think about the group activities to recapitulate the contents of the previous course days?

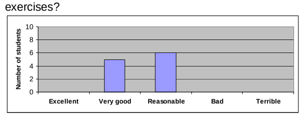
(1 student didn't answer)

7. How was the subject of the cloning lab connected/aligned to the disease lecture?

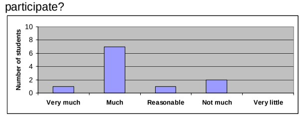
8. How was your overall learning motivation during the cloning lab?



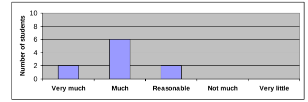
9. How was your overall learning motivation during the other lab exercises?



10. Did the questions during lecture/exercise motivate you to actively participate?

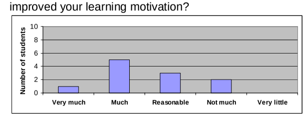


11. Did the participation in a research-based exercise with uncertain outcome (open-end) improve your learning motivation?

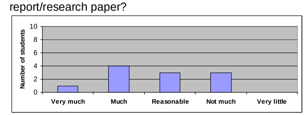


(1 student didn't answer)

12. Did the task to write a lab report in form of a research paper improved your learning motivation?



13. How much did you learn from the preparation of the lab report/research paper?



14. Specific comments: What did you like/didn't like? What would you improve/change?

- "Overall good!"
- "Disliked the group aspect a little bit, would be better if we´re encouraged to write and hand-in lab report after each day"
- "As I have done a lot of reports, the outcome of that part was limited, but for people with no such experience it is a very good exercise. "

8

Undervisnings- og læringsaktiviteter i et traditionelt kursus i økonomisk teori

Lill Andersen

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Problem definition

Kurset *Economic growth and development* er et traditionelt kursus i økonomisk teori. Mange af kursets ILO'er handler om declarative knowledge, men det ultimative mål med undervisningen er functioning knowledge, undervisningsformen er traditionelle forelæsninger og små teoretiske opgaver, og assessment sker i form af en skriftlig sluteksamen uden hjælpemidler. Min erfaring efter at have undervist i kurset én gang er, at der ikke er god alignment mellem ILO'er, TLA'er og assessment, og at jeg mangler feedback om de studerendes faglige niveau under kurset.

I dette projekt vil jeg søge at finde frem til alternative undervisnings- og læringsaktiviteter (TLA'er), der sikrer en bedre alignment og kan anvendes i en klasseværelsessituation som den eksisterende givet de eksisterende læringsmål (ILO'er). Jeg vil fokusere på TLA'er, der aktiverer de studerende og giver såvel dem som underviseren feedback, og jeg vil beskrive, hvordan de praktisk kan implementeres på kurset.

Kurset Economic growth and development

Economic growth and development er et valgfrit $7\frac{1}{2}$ point kandidatkursus, der blev udbudt for første gang i blok 3, 2009. Ifølge kursusbeskrivelsen er "...the main objective of the course ...to provide an introduction to economic growth, income inequality, growth mechanisms, and fundamental characteristics that influence the economic development of countries."

Jeg har tidligere reflekteret en del over målet med undervisningen, herunder opdelt kurset i 6 temaer og opstillet detaljerede delmål for hvert tema. Declarative knowledge, der omfatter, at de studerende bliver bekendte og fortrolige med notationer, antagelser og matematiske teknikker, fylder en del i kurset, men det ultimative mål med læringen er functioning knowledge - at de studerende bliver i stand til reflektere over antagelsernes betydning og resultaternes relevans i et empirisk perspektiv, og at sammenligne forskellige vækstteoretiske modeller mhp. at udvælge de bedste metoder til økonomiske analyser.

Under kurset oplevede jeg, at det var vanskeligt at få de studerende til at læse – generelt og specielt før undervisningen - og at engagere dem i de teoretiske øvelser. Det er ærgerligt, da der er skrevet nogle rigtig gode lærebøger om emnet, og viden transmitteres mere effektivt til de studerende gennem deres aktive læsning af disse frem for passiv deltagelse i mine forelæsninger (Mazur; 1997). Eksamen afslørede desuden, at de havde lært mindre end forventet om nogle af temaerne – fx havde mange en ringe forståelse for den økonomiske betydning af modellerne og var dårligere end forventet til at anvende dem. Det tager jeg som et udtryk for den ringe alignment mellem ILO'er, TLA'er og assessment. Forelæsningerne fyldte for meget, hvorved der blev for stor fokus på, hvad jeg som underviser gjorde og for lille fokus på, hvad de studerende gjorde givet de anførte ILO'er. Den skriftlige sluteksamen uden hjælpemidler lagde heller ikke op til en dybere forståelse af stoffet og en anvendelsesorienteret tilgang.

Alternative TLA'er

Hvilken TLA, der mest effektivt transmitterer viden, afhænger af den specifikke ILO, der adresseres. Ikke desto mindre fremhæves nogle generelle karakteristika ved gode TLA'er i literaturen. Biggs and Tang (2007) nævner således følgende karakteristika (kap. 6):

a. At der eksisterer et såkaldt Theory Y klima (hvor læreren har tillid til de studerende og antager, de gør deres bedste), at de studerende opfatter TLA'en som havende en værdi, og at de studerende har en rimelig chance for at nå målet;
b. At der bygges ovenpå det kendte både vertikalt og horisontalt – dvs. at undervisningen skal vise sammenhængen mellem de forskellige emner, og den konceptuelle struktur i det lærte;

c. At TLA'en involverer relevante aktiviteter, hvorigennem den studerende får mulighed for at lære gennem forskellige sanser: høre-, føle-, syns-, tale-, lugte- og smagssansen;
d. At der gives formativ feedback med det formål at hjælpe læringsprocessen i den rigtige retning – af læreren, af medstuderende og/eller af den studerende selv;
e. At de studerende får mulighed og tilskyndes til at reflektere over deres egen læring.

Ad a) Jeg mener, der var en god stemning på kurset, at de studerende var trygge ved at sige noget, og at de krav der blev stillet var af en passende karakter. Men de studerende havde svært ved at se værdien af nogle af de teoretiske opgaver, da de var for afgrænsede og ikke fik relateret teorien til virkelighedens verden i tilstrækkeligt omfang;
Ad b) Jeg mener, der bygges fint oven på det, de studerende har lært i forudgående kurser i matematik og økonomisk teori, og der er en god struktur i de emner, kurset dækker;
Ad c) Det skete ikke, og jeg mener også, det er meget vanskeligt at lære økonomisk teori med lugte- føle- og smagssansen. Men det er sikkert bare mangel på fantasi fra min side;
Ad d) Jeg var indstillet på at give formativ feedback på de teoretiske opgaver. Desværre afleverede kun en gruppe systematisk opgaverne – jf. ad a).
Ad e) Det skete sandsynligvis ikke pga. undervisningsformen.

I det følgende vil jeg beskrive to forskellige TLA's, der begge fokuserer på, hvad den studerende gør, frem for hvad læreren gør. Derved involveres de studerende mere aktivt i undervisningen end gennem en forelæsning. Desuden er der fokus på at give de studerende nyttig feedback. Den ene metode er udviklet og anvendt af Eric Mazur i fysikundervisning på Harvard, mens den anden stammer fra Niels Grønbæks matematik-kursus på NAT. Herefter vil jeg give et bud på, hvordan undervisningen i kurset *Economic growth and development* kan bygges op omkring disse TLA'er frem for traditionelle forelæsninger og teoretiske øvelser.

Eric Mazurs undervisning

(Mazur; 1997; Biggs and Tang; 2007, pp. 104–134)

At lytte er ikke så effektiv en måde at lære på som at læse. Eric Mazurs TLA'er skal derfor sikre, at første gang, de studerende stifter bekendtskab med ny viden, sker det gennem læsning og ikke gennem en forelæsning. Således får de studerende en tekst, der skal læses før undervisningen, og undervisningen starter med en mini quiz om dette materiale. Quizzen tester kun om de studerende har læst – den tester ikke, om de har forstået det, de har læst, fordi hvis den gjorde det, ville den straffe de studerende, der har læst men ikke forstået.

Resten af undervisningstiden opdeler Mazur i 10-15 minutters intervaller, hvor der fokuseres på de vigtigste pointer i det læste. Hver periode indledes fx med en kort forelæsning, hvorefter der stilles multiple choice spørgsmål, der tester de studerendes forståelse. Når de studerende individuelt har besvaret spørgsmålet, skal de forsøge at overbevise en anden studerende om, at de har valgt det korrekte svar. Efter denne diskussion med sidemanden, skal de studerende igen besvare spørgsmålet, og det har vist sig, at andelen af studerende, der vælger det rigtige svar, stiger efter diskussionen. Det tyder på, at de studerende er i stand til at forklare svaret for hinanden og dermed undervise hinanden.

Ovenstående undervisningsforløb involverer de studerende aktivt i undervisningen – både mht. at læse stoffet frem for at få det gennemgået via en forelæsning og anvende det aktivt på multiple choice spørgsmålene. Den efterfølgende diskussion uddyber deres forståelse, da de tvinges til at argumentere for deres svar og diskutere det med medstuderende. Undervisningen giver også de studerende umiddelbar og brugbar feedback – både fra medstuderende og fra underviseren. Underviseren får også værdifuld information om de studerendes forståelse af stoffet gennem svarene på quizzen og multiple choice spørgsmålene.

Niels Grønbæks undervisning

(Grønbæk (2009))samt foredrag af Niels Grønbæk på adjunktpædagogikumkursus den 11. Dec. 2008)

Niels Grønbæks TLA'er har også fokus på aktiv deltagelse og feedback. Den værktøjsmæssige håndtering af stoffet trænes gennem ugentlige opgaver, der besvares individuelt. Det mere teoretiske stof deles op i 7 temaer, som hver varer en uge. Hver uge starter med en kort forelæsning, der introducerer temaet. Herefter udleveres en liste med opgaver og øvelser, som de studerende arbejder på i grupper. Opgaverne/øvelserne er twists af lærebogens teorier, hvilket giver de studerende mulighed for at arbejde selvstændigt med de teoretiske dele af kurset. Temapapirer med de studerendes besvarelser/reflektioner over opgaverne afleveres, og de studerende får skriftlige kommentarer. Disse temapapirer er desuden grundlaget for den mundtlige eksamen i kurset. Afslutningsvist har de studerende en uge til at forbedre alle temapapirerne som forberedelse til eksamen.

Denne undervisningsform sikrer, at de studerende får kontinuerlig feedback - fra medstuderende gennem gruppearbejdet og fra underviseren gennem skriftlige kommentarer til temapapirerne. Desuden sikres en god alignment mellem ILO'er, der involvere, at de studerende skal kunne anvende, analysere, forklare, løse problemer, TLA'er og eksamen gennem det aktive arbejde med temaopgaverne og eksamensformen. Endelig har metoden den fordel, at de studerende stifter bekendtskab med eksamensspørgsmålene fra dag 1 af, hvilket måske mindsker usikkerheden omkring eksamen, og den naturlige fokus på eksamen udnyttes konstruktivt. Omvendt kan det, at opgaverne og øvelserne i temapapirerne er twists af lærebogens teorier sandsynligvis give anledning til en vis utryghed. Denne kan evt. mindskes gennem underviserens feedback, ligesom incitamenterne til at aflevere temaopgaverne evt. kan påvirkes positivt at dette.

Eftersom omfanget af forelæsninger også på dette kursus er begrænset, tvinges de studerende til at lære gennem at læse lærebøger/anden tekst frem for ved at lytte til en forelæsning – som på Eric Mazurs kursus. Og på begge kurser har de studerende incitamenter til at læse, før undervisningen, da de ellers ikke kan besvare multiple choice opgaverne og ikke kan besvare temaopgaverne.

TLA'er i kurset Economic growth and development

Med henblik på at sikre, at de studerende både får fyldt værktøjskassen op med teknikkerne til at løse og anvende de teoretiske modeller og bliver i stand til at anvende og forholde sig kritisk til teorien og de specifikke modeller, deles kurset op i 7 temaer af en uges varighed hver. Hvert tema indeholder:

- Arbejde med at læse relevante udsnit af lærebogen eller anden relevant tekst før undervisning med henblik på at tilegne sig ny viden gennem det læste frem for via en forelæsning;
- Et par multiple choice spørgsmål á la Eric Mazurs miniquiz, som de studerende først besvarer individuelt, hvorefter de diskuterer og søger at overbevise hinanden om svarene i grupper. Disse spørgsmål vil typisk teste de studerendes tekniske viden – ikke om de er i stand til at anvende

den – blot om de har forstået de teknikker, der anvendes i det læste. Det vil give dem mulighed for at forklare det, de har læst samt give og modtage værdifuld feedback, og det vil give mig værdifuld information om, hvor der er forståelsesmæssige problemer, der skal løses, inden de kan komme i gang med temaopgaven

- en kort (10-20 minutters) forelæsning, der typisk vil relatere det læste teoretiske stof til empirisk evidens i form af økonometriske undersøgelser eller cases. Formålet med dette er at sikre mig, at de studerende kan se relevansen og meningen med at beskæftige sig med den teori
- resten af arbejdet med temaet foregår i grupper, hvor de udarbejder et temapapir, som afslutningsvist afleveres til mig med henblik på formativ feedback. Formålet med dette arbejde er, at de studerende skal lære at anvende de teoretiske modeller, reflektere over deres præmisser og forklare og diskutere udfaldet af dette arbejde. Jeg vil være til stede en del af tiden, men jeg vil også forvente, at de bruger tid på opgaven ud over de afsatte 12 timer i undervisningslokalet.

Som i Niels Grønbæks kursus får de studerende en uge til at gennemskrive deres temapapirer. Assessment kan enten ske i form af en mundtlig sluteksamen med udgangspunkt i temapapirerne eller selve temapapirerne kan danne grundlag for en portefolioeksamen. Under alle omstændigheder skal kvaliteten af temapapirerne tælle med i den endelige bedømmelse for at øge incitamenterne til at arbejde med stoffet og evt. udarbejde noget skriftlige materiale, der kan give inspiration ved specialeskrivningen. Hvilken løsning, der vælges, afhænger af de praktiske muligheder mht. fx individuel eksamen mv.
De 7 temaer kunne være følgende:

1. Fysisk kapitalakkumulation som den primære vækstmotor?
   - De studerende læser om Solow-modellen med eksogen opsparingsrate og fysisk kapitalakkumulation
   - Forelæsningen beskriver den empiriske evidens for at fokusere på fysisk kapital som vækstmotor
   - Temaopgaven handler om Solowmodellen med en eksternalitet i form af fysisk kapital: de studerende skal udlede steady state i denne model og illustrere steady state og transitional dynamics grafisk, reflektere over hvad en eksternalitet er, og løse en variant af modellen med konstant afkast til fysisk kapital og relatere løsningen til Solow-modellen i lærebogen (ny kontra gammel vækstteori)

2. Husholdningernes adfærds betydning for væksten - og omvendt
   - De studerende læser om Solow-modellen med husholdninger, der maksimerer nytten ved at vælge det optimale forbrug over tid
   - Forelæsningen fokuserer på vigtigheden af at modellere forbrugernes adfærd i en vækstanalyse – i et empirisk perspektiv (muligvis historisk perspektiv – unified growth theory)
   - Temaopgaven handler om Solowmodellen med husholdninger, der maksimerer nytten både mht. forbrug og fritid: de studerende skal udlede steady state i denne model, lave en policyanalyse af effekten af bistand og reflektere over resultatet i lyset af empirisk evidens vedr. sammenhængen mellem vækst og bistand
3. Human kapitalakkumulation som den primære vækstfaktor?
   - De studerende læser om Solow-modellen med human kapital i lærebogen
   - Forelæsningen beskriver den empiriske evidens for at fokusere på human kapital samt konvergensdebatten
   - Temaopgaven handler om Lucas-modellen (ekskl. Lucas' eksternalitet): de studerende skal udlede steady state, beskrive transitional dynamics, beskrive og forklare forskellene mellem Solow-modellen med human kapital og Lucas-modellen (ny kontra gammel vækstteori), lave en komparativ statisk analyse af effekterne af øget opsparingsrate og relatere til konvergensdebatten
4. Produktivitetsvækst via horisontal innovation
   - De studerende læser om den semi-endogen version af Romer-modellen i lærebogen
   - Forelæsningen beskriver den empiriske evidens for hhv. produktivitets og faktorrakkumulations betydning for vækst- og indkomstforskelle
   - Temaopgaven handler om den oprindelige Romer-model: de studerende skal udlede steady state i modellen, sammenligne med den semi-endogene version og reflektere over begge modellers velfærdsimplikationer – herunder forholde sig til forskelle og ligheder
5. Produktivitetsvækst via vertikal innovation
   - De studerende læser om en model med vertikal innovation
   - Forelæsningen fokuserer på forskellen mellem vertikal og horisontal innovation samt begrebet creative destruction
   - Temaopgaven handler om en multisektor variant af modellen med både vertikal og horisontal innovation: de studerende skal udlede steady state, sammenligne resultaterne med hhv. den semi-

endogene version af Romer-modellen og den oprindelige Romer-model og forholde sig til skala-effekten

6. International handel og vækst?
   - De studerende læser om en vækstmodel for en åben økonomi med horisontal innovation
   - Forelæsningen fokuserer på empiri vedr. væksteffekter af international handel
   - Temaopgaven handler om Rivera-Batiz og Romers lab equipment model: de studerende udleder steady state i modellen, analysere effekterne af international handel og sammenligne disse med effekterne i den model, de har læst om
7. International diffusion af generel viden?
   - De studerende læser om en model med horisontal innovation og en international knowledge externality
   - Forelæsningen fokuserer på forskellen mellem teknisk, specifik viden og generel viden - og empiri vedr. betydningen af hver slags videndiffusion
   - Temaopgaven handler om en variant af modellen, hvor videnseksternaliteten er national: de studerende udleder steady state i modellen, beregne effekterne af international handel og sammenligner effekterne i denne model med effekterne i en model, hvor videnseksternaliteten er international.

Hvert enkelt tema giver mening og værdifuld viden i sig selv. Samtidig er der forbindelser mellem temaerne: emner som konvergens, skalaeffekter og effekter af international handel går på tværs af temaerne. Arbejdet med at løse modellerne vil sandsynligvis tage en del tid i flere af temaerne. Ved en mundtlige eksamen vil der ikke være fokus på dette tekniske arbejde, men det er OK, at det tager en del tid under gruppearbejdet, da det at kunne det er en forudsætning for at kunne anvende modellerne til politikanalyser mv. Under eksamen vil der derimod være fokus på den økonomiske mening og forståelse af modellerne samt sammenligning af antagelser eller resultater på tværs af modellerne.

Afrunding

Med de rette temaopgaver er det min overbevisning, at der kan opnås en bedre alignment i kurset *Economic growth and development* med de ovenfor beskrevne TLA'er. TLA'erne aktiverer de studerende og giver såvel de studerende som underviseren nyttig feedback.

Men alt afhænger af temaopgaverne. En samling af små, afgrænsede teoretiske opgaver vil ikke give de studerende det ønskede helhedsbillede af vækstteori og dens muligheder og begrænsninger. Hver temaopgave skal være sammenhængende, af passende sværhedsgrad i forhold til det læste og de studerendes matematiske baggrund, og anses for at være relevant af de studerende. Endvidere skal temaopgaverne bindes sammen gennem spørgsmål, der relaterer til tidligere temaer.

9

Advanced spectroscopy (M-337) in the block structure

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Introduction

The course in advanced spectroscopy will be given in the ”block structure” in the autumn of 2010 and the course description, objectives, teaching activities and evaluation should be reviewed well in advance to make the transition smooth. This is also a good opportunity to consider improvements in the course and to test new ideas with the students at the next course (which will be the last time the course is given outside the block structure).

Problem definition

The intended outcomes of the project are:

- A suggestion of how to use the block structure to organize the course including the evaluation which currently is a three weeks project work.
- A reviewed course description.
- A poster to attract students to this elective course (and presentable at the meeting in August).

The first point, how to organize the course within the frames of the block structure, will give me an opportunity to plan a course without starting from scratch. Since I have been involved as a teacher in this course it will also fit into my portfolio. For this project I’ll consult with collogues and former students to establish the key elements of the course, if there is any perceived difficulties and how well the examination works.

Excerpts from the current course description

The course is currently worth 6 ECTS-points and running over approximately 14 weeks.

The course aims to introduce students to the practical application of modern spectroscopic methods. The course focuses on methods used to determine the structure of organic compounds, including determining relative stereochemistry and, less commonly, absolute stereochemistry.
Main course emphasis is on problem solving. The course will illustrate ways of using different spectroscopic methods to determine structure and identify small to medium size organic compounds, on their own or in combination.

The course is largely taught in double lessons so that after an introductory theoretical review, students can solve problems illustrating the theory. Computer programs for processing data and analyzing NMR spectra will be used during the course in order to provide students with deeper understanding of NMR theory. Most of the practical exercises will be done as homework assignments.

At the end of the course students in groups of two will be given a collection of spectra (typically MS, IR, UV and various NMR spectra) for an organic compound and asked to identify the compound based on these spectra to the extent possible. The NMR spectra are typically provided as raw digital data (FID's) to be processed by students in order to identify the related spectra.

Three weeks after the spectra have been provided, students must hand in a written report in which they give an account of the structural explanation for the compound. During these three weeks students may have up to 45 minutes of assistance from the supervising teacher. In order to be evaluated individually on the basis of the 7-point scale, students will subsequently be examined orally on their written report.

Teaching in the block structure

Teaching at the pharmaceutical faculty will be organized into four blocks instead of the current system of two semesters. This is an ongoing reform to increase the potential for mobility of students both within and between the universities and faculties. It is also a good opportunity to introduce new forms of teaching and evaluation methods (Horst and Winsløw; 2004).

The block structure in itself is supposed to make the education more effective by making room (time) for longer periods of organized student group work. The teachers' role will be to introduce subjects and exercises to the students, guide the exercise and to follow up on the results. The students will learn the subject while working in groups and during the follow up. This is in contrast to today, where students are supposed to do their homework before and after lectures, combined with a few exercise classes.

	Before	Lecture	In between	Exercises
Teacher	Preparation	Lecturing	Preparation	Guiding
Student	Reading (maybe)	Listens/takes notes (maybe)	Reading, writing, calculates (maybe)	Takes notes, participates

Fig. 9.1. Traditional organization of the teaching/learning process.

	Class	Working time	Class
Teacher	Introduction of new subjects, present exercises for the students	Guides, supervises and observes students' progress	Recapitulation of difficult issues in the exercises
Student	Listens/asks questions/takes notes (checked)	Working with exercises (checked)	Listens/asks/notes/ discusses/presents

Fig. 9.2. Teaching in the block structure

Time frame

One block stretches over 9 weeks, representing 15 ECTS-points. A course covering 7.5 ECTS-points will be assigned one out of three possible schedule groups (A, B and C) each allowing teaching during a whole day and either a morning or afternoon session per week. The maximal total time for one block will be 12 hours per week, if the morning session starts at 8:00 and the afternoon session continues to 17:00. The exact time frame can, however, be decided on by the teacher as long as it does not come into conflict with the other schedule groups (see http://www.science.ku.dk/udregler/forside/undervisningen/skemagrupper [2009-08-25]. There is still no description of the schedule groups in the block structure at the faculty of pharmaceutical sciences (www.farma.ku.dk), but they are (probably) the same for the whole university).

	Mon	Tue	Wed	Thur	Fri
Morning session -12.00	B	A	C	A	B
Afternoon session 13.00-	C	B	C	A	

Fig. 9.3. The A, B and C-blocks of the blocks structure

Teaching advanced spectroscopy in the block structure

The current organization of 'Advanced Spectroscopy' (M-337) is based on in general two hours of lectures, twice a week. At present, there are in total 19 lectures spread over approximately 10 weeks. For the time between lectures, smaller assignments are presented to the students. At three occasions during the course, a four hour guided afternoon session of computer exercises were scheduled (see Appendix A). The final exam is in the form of a project work running over four weeks. The students are given raw NMR-data and a mono isotopic mass and from this they should determine the structure of a natural product. There is a limited time, 45 minutes, to discuss the project with the one of the teachers. The number of enrolled students is 28 this year and is expected to be this size the first time the course is given in the new structure next year.

To find out more about the key points of the course and the most important and relevant subjects I arranged an interview with a few students. They were selected based on their previous participation and their current positions as PhD-student and finishing master theses at the department. The idea was that they could pinpoint the merits of the course and have suggestions for the reorganized course. For a list of questions and compiled answers – see page 83. I have also talked to some of the other teachers active on the course and reviewed the lecture slides from last and previous years.

Organization

The block structure and the currently planned schedule group (A) include a 'short day' and a 'long day' per week. To keep the current number of lectures would require about three occasions per week for six weeks, leaving time for three weeks of final project work. Considering the workload of the teachers and students, I believe it would be best to aim for lectures twice a week as it is today. However, this means that the lectures must be more streamlined (less overlap) and with considerable less repetition compared to the current situation. By introducing group assignments or smaller projects linked to the lectures it would be possible to reduce the time spent for repetition and at the same time get control over how much the students have actually learned from the lectures.

The interviewed students expressed that it was important that the time in class was effective without too much dead time. Presentation of group work should hence not be placed in the end of a long day. Time planned by themselves, such as group work and computer exercises, could be stretched out if needed, but if they had to prioritized otherwise they could do the work without guidance.

My suggestion of a framework is two-hour lectures twice per week (separate days). The rest of the time should be used for exercises solved by working in smaller groups (with some supervision) or individually, supervised computer exercises and demonstrations/hands on sessions. Group works should be presented to the rest of the groups during sessions moderated by the teachers.

A week could start (short day) with the presentations of one or two student's solutions to previous exercises/assignments with discussions led by the teacher. After this a lecture introduces new issues and exercises to be solved in groups. The bulk of the group work is done during the 'long day' with some support from the teachers. The afternoon session starts with presentations, followed by a new lecture and exercises to be solved over the weekend (individually or in group). However, the lecture should probably not take place too late in the afternoon so the presentation of results might be placed before lunch. Some of the ‘long days’ are used for the supervised computer exercises and demonstrations/hands on sessions in the instrument lab.

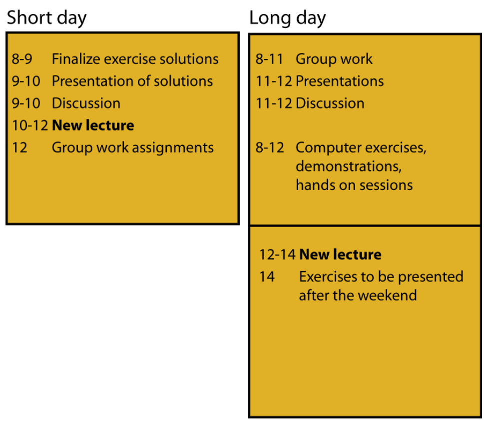

Fig. 9.4. Suggestion of framework for the organization of the course

Course outline

From the current syllabus a slightly compressed outline of the course is presented under Appendix A. The exact content depends on the choice of textbook and the teachers involved in the course.

Examination

The students were very satisfied with the final project work as exam. It was a good motivator to put a lot of work into the course and they had good use of the knowledge they gained from it.

For the reorganization of the course it makes sense to keep this form of evaluation. They expressed that the time for the project (3-4 weeks) was well suited to the problem and close to what would be required of them if it was a real problem. However, they thought there could be more ‘milestones’ such as “all data processed and ready for interpretation” and more guidance of how to organize the actual data interpretation.

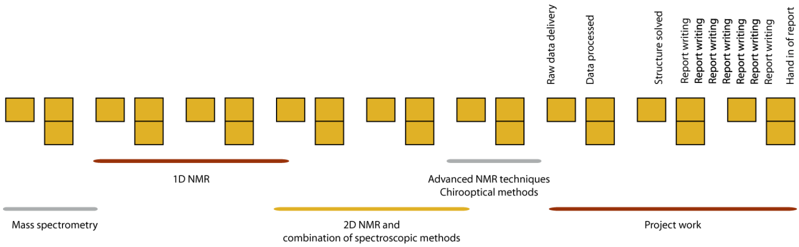

Fig. 9.5. Outline of the course. Each of the nine weeks are represented by three schedule blocks –one short day and one long day.

Course outcome

The current course outcome (Figure 9.6) is a bit outdated compared to the actual syllabus. My suggestion is presented below with verbs from ‘Bloom’s revised taxonomy’ of intended learning outcomes (Biggs and Tang; 2007, p. 81) without the present use of prefixed “To be able to. . . ” From the interview I learned that the main merit of the course was the *exposure* to NMR and the combination of different experiments to deduce the structures of the molecules. At this, the exam work was well aligned to the objectives of the course and the syllabus. However, the students thought there could be a larger proportion of mass spectrometry since different MS techniques (MALDI-TOF, DESI, MS^n) generally are used in real life structural determinations.

At the end of the course, students are expected to be able to use IR, UV, ^{1}H NMR, ^{13}C NMR and mass spectrometry for the structural determination and identification of organic compounds, including:

- To be able to interpret first order coupling patterns as well as simple second order coupling patterns in ^{1}H NMR spectra
- To be able to predict ^{1}H and ^{13}C NMR chemical shift values for small to medium size organic molecules and use them to solve structural problems
- To be able to intrepret homo- and heteronuclear 2-D NMR experiments such as COSY, NOESY, HSQC and HMBC
- To be able to explain fragmentation patterns in EI mass spectra and to be familiar with other techniques/ionisation forms of mass spectrometry.

Fig. 9.6. Current course outcome as described on http://www.farma.ku.dk

The students are expected to use ^{1}H NMR, ^{13}C NMR and mass spectrometry in combination for the structural determination and identification of organic compounds, including:

- Interpret first order coupling patterns as well as simple second order coupling patterns in ^{1}H NMR spectra
- Predict ^{1}H and ^{13}C NMR chemical shift values for small to medium size organic molecules and use them to solve structural problems
- Intrepret homo- and hetero nuclear 2-D NMR experiments such as COSY, NOESY, HSQC and HMBC to deduce structural fragments and their connections
- Explain fragmentation patterns in EI mass spectra and to be familiar with other techniques/ionisation forms of mass spectrometry.

Fig. 9.7. Suggested intended learning outcome

Perceived difficulties and problems with the course

Computer exercises

The handling of the NMR computer program (Topspin) took a lot of energy. The suggestion to overcome this was more guidance. Also, the actual workflow with the data handling could be more thoroughly described.

The Topspin-program is not freely available to the students after the course. It was suggested to use another program, ACD, instead. For this program we have a site license and it is regarded as more intuitive. This would require the teachers to learn this program.

It was also suggested to keep the theory of NMR and NMR-processing away from the computer exercises. They ended up changing parameters in a program they did not fully master. The adjustment of these parameters is also not that important during the exam project work (or for their theses).

Scientific writing

The interviewed students thought that a descriptive way of the reasoning leading to the structure was the best for the exam work. However, they also meant there could be room for guided reading and writing of a scientific text directed to the subject. The report could contain an ‘Experimental’ section describing the relevant parameters for the experiments.

Time for the exam project work

Teaching in the block structure means a more time compressed course and the students thought it was valuable to work during a longer period with the final project. However, it was not a solution to hand out and start the exam earlier since this should make the students to lose their focus. Also, the time frame to solve a structure in reality should not take too much time. However, it was suggested to introduce additional 'milestones' during the project, such as 'all data processed and ready for interpretation'. At present we check that the obtained structure is correct before the report is finalized.

No practical lab work

It should add value to the course if there was time to actually acquire a real spectrum. Ideally, all the spectra for the final project work should be set up and ran. It would be possible, but requires quite a lot of work from the teachers' side. A set of spectra could be acquired within hours if the sample was of high concentration and with the proper automation.

Interview of previous students in the course

Participants and year for the course: Lasse Saaby (2007, PhD-student), Rasmus PW Larsen (2008, finishing master thesis) and Jeppe Secher Schmidt (2008, finishing master thesis). They have all been using the techniques and methods taught during the course for their master theses.

1. **Was the course good or was it 'a waste of time'?**
   This is just to get them started…
   The course was regarded as a very good one. The best point was the *exposure* to NMR and the use of combined experiments to solve a problem (more than in M-25 and the whole arsenal of different experiments). The exam, project work, was also appreciated and well connected to the syllabus.
2. **Was the allocation of time for the different subjects ok?**
   MS: 3 lectures (each 2 hours)
   General NMR: 10
   2D NMR: 3
   Hyphenation and combined use: 2

Computer exercises: 3 occasions (each 4 hours)
Yes, but more MS could be included. Although, there was very little MS in the project work (just a mono isotopic mass given) but mass spectroscopy is in reality used more.

3. **Would it be possible to introduce the 2D-NMR at an earlier stage?**
2D NMR is a large part of the project work, but emerges at a late stage.
No. The focus group agreed that a logical structure of the course is important – first theory, then 1D followed by 2D.
4. **Were the computer exercises adequate?**
There were three occasions with computer exercises. The project work required use of a special NMR program.
The handling of the computer program took a lot of energy. There was two good suggestions – to offer guidance when the raw data files are delivered, and to have 'milestones' in the project such as 'All data processed and ready to be interpreted'. Also, they thought that some guidance of how to handle all the data would be good.The computer exercises should not be used to exemplify theoretical issues (such as digital resolution), only the practical steps needed.
5. **Did the lectures prepare you for the project work?**
The project work ran for a period of four weeks. From spectra to structures, and to explain the spectroscopic features.
In general, yes. But some more guidance of how to practically work with all the data would be good.
6. **What kind of problems in a more 'problem based education' would be suitable for a course like this? Give examples from your current situation in the lab.**
Teaching in the block structure is meant to be more problems based compared to traditional teaching in order to activate the students and making the teaching efficient. (Think of working in groups with problems presented during a lecture.)
Exercises from the book is ok, but some of them was cryptically, silly (tåbelig) and very theoretical. If possible they should be reworked to make them more relevant and case based.Solutions to some practical exercises should be presented by the students for the whole group. A suggestion was that all groups worked on the same problem, but only one presented the results and led the discussion of how to work with this particular problem.Also, a time limited real case, say 2 hours from raw data to identified fragments, could be used as a model of how to work with NMR and how much information could be extracted in a

short time. It was stressed that an efficient use of the long days was important. Group work with a summing up late in the afternoon might bore the students. Keep the summing up to the next occasion and give the student liberty to plan their work.

7. **What style do you prefer to use for the report?**
Do you prefer 'the scientific description' (full structure with the spectroscopic features described) or 'Sherlock Holmes' (from spectra to fragments to molecule)? What style would prepare you the best for tasks after the course?
The focus group liked the 'Sherlock Holmes'-style best because it gave them best possibility to write about the logical steps necessary to reach the final structure. Also, there was space to consider alternative fragments, and how to select among these.
8. **Was the long time given for the project work valuable?**
The time from delivery of raw data files to submission was 3 or 4 weeks.
Yes, the relatively long time was valuable to let the project settle in their minds. The block structure will mean a shorter, but more focused, time. Still, they thought it was important not to start the project work too early, before the bulk theory had been processed. It would put the students in 'exam mode' and draw attention from the theory and practicalities of the course.
9. **What new elements would you like to see?**
The new course will be slightly longer. 7.5 ECTS instead of 6 ECTS.My suggestions: Quantitative NMR, chemometrics, other pulse sequences, MALDI-TOF MS, HPLC-MS, practical lab work, acquisition of spectra, other computer programs, scientific writing
More mass spectrometry (HPLC-MS, GC-MS, multiple stage fragmentation, MSn, peptide analysis, other ionization techniques, MALDI, DESI) because it is a valuable technique in the analysis of natural products. The isotope pattern is theoretically important, but is not used in practice (or in the final exam).
Quantitative NMR – yes!
Chemometrics – introduction with practical examples to give a perspective.
Other pulse sequences – not necessarily, but more about different variants of the used sequences (different mixing times in HMBC, different filters, phase sensitive experiments, multiplicity editing in 2D hetero nuclear NMR).
Practical lab work, acquisition of spectra – Yes! In an advanced course

it should be time to acquire at least some simple spectra. The longer days in the block structure could be used for this.
Other computer programs – Yes! It's better to learn ACD (for which there is a site license) compared to learning Topspin (no license, not too intuitive).
Scientific writing – Yes! Maybe adding an 'Experimental' section to the project work. Also, reading of scientific articles to learn how the subject is described.

A Appendix: The schedule for M-337 2009

Advanced Spectroscopy M-337-3 Autumn 2009

#	Date, time, room	Subject	Teaching material*	Teacher(s)**
1	31/8 10.00-12.00 (U22)	The mass spectrometer, EI, the molecular ion	13.3 + 13.3a + 13.4a + 15.3-15.4b, MS Notes 1-5, Exercises in Notes	SBC
2	4/9 8.00-10.00 (U8)	Alternative ionization, fragmentation	13.3b-13-3e + 14.1, 14.2-14.6	SBC
3	7/9 10.00-12.00 (U22)	Detection, fragmentation	13.4b-4f + 14.2-14-6	SBC
4	11/9 8.00-10.00 (U8)	Introduction to NMR	2.1 + 2.2 + 2.5 + 2.6 + 2.7	NN
5	14/9 10.00-12.00 (U22)	Vector model, relaxation, pulsed experiments	2.3 + 2.4	NN
6	18/9 8.00-10.00 (U8)	Experimental methods, spectrometer, processing of NMR signal, acquisition parameters, dynamic effects	2.8 + 2.9	NN
7	21/9 10.00-12.00 (U22)	^{1}H chemical shifts	3.1 + 3.2	SA
8	25/9 8.00-10.00 (U8)	^{13}C chemical shifts	3.3 + 3.4	AY
9	28/9 10.00-12.00 (U22)	First order coupling patterns	4.1-4.8	NN
10	29/9 12.15-16.15 (D1)	**Computer exercises**	Hand-outs	NN/AY
11	2/10 8.00-10.00 (U8)	Higher order coupling patterns	4.1-4.8	NN
12	5/10 10.00-12.00 (U22)	Coupling constants and structural relationships	4.1-4.8	NN
13	9/10 8.00-10.00 (U8)	Relaxation, decoupling nuclear Overhauser effect	5.1 + 5.3 + 5.4	NN
14	19/10 10.00-12.00 (U22)	2D-NMR: COSY, TOCSY	6.1	JJ
15	20/10 12.15-16.15 (D1)	**Computer exercises**	Hand-outs	NN/JJ
16	23/10 8.00-10.00 (U8)	2D NMR: NOESY, INADEQUATE	6.3 + 5.7 + 6.4	JJ
17	26/10 10.00-12.00 (U22)	2D-NMR: HSQC + HMBC	6.2 + 6.6	JJ
18	30/10 8.00-10.00 (U8)	Spectral editing, sensitivity enhancement	5.5 + 5.6	NN
19	2/11 10.00-12.00 (U22)	Hyphenated NMR methods: theory and applications	Hand-outs	JJ
20	3/11 12.15-16.15 (D1)	**Computer exercises**	Hand-outs	NN/JJ
21	6/11 8.00-10.00 (U8)	Chiroptical methods: CD, ORD	10.1, 10.3, 11.1-11.1a, 11.2-11.2c, 11.5a, 12.2-12.2a Use of molecular model set is recommended	JJ
22	9/11 10.00-12.00 (U22)	Combined use of spectroscopic methods	Hand-outs and selected exercises from Chapter 16	JJ

*Sections in Lambert, J.B., Shurvell, H.F., Lightner, D.A. & Cooks, R.G., Organic Structural Spectroscopy, Prentice-Hall 1998. **JJ: Professor Jerzy W. Jaroszewski (responsible for the course); SBC: Docent Søren Brøgger Christensen; NN: Dr. Nils Torsson Nyberg; SA: PhD-student Sara Angolet; AY: PhD-student Ali Yilmaz

10

Biology A1: Correlations between the exam results and evaluations – Reflection on teaching methods and student outcome

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Introduction

In this project, I have chosen to analyze if there is a correlation between the exam results and the student evaluations. I will keep the main focus on the Plant Biology part of the Biology A1 course (2007), in which I have been involved in development and teaching of the exercises and preparation of the exam questions.

Biology A1: Cell biology – from organism to molecule

The course consists of 21 lectures (1h) and 21 exercises (2h), divided between 3 main teachers of which each have their own spatiality. The 3 teachers have further divided their individual part of the teaching on one or more post-docs or PhD students.

The course is obligatory for biochemistry students on their first year (block 1), and together with A2 (the second part of the Biology course) the main objective of the course is to introduce the main principles and key issues of modern biology incl. living organisms' form and function, cell biology, molecular biology and genetics. Furthermore the students should gain basic understanding of concepts, which will enable them to solve biochemical and biological problems related to their education

The A1 part of the course will focus on: the basic anatomy of plants and animals, organs, tissue, the basic structure and functions of cells, organelles and membranes, the cell cycle and cell division, and the structure of macromolecules. For a complete course description, see Appendix A.

The students are evaluated using a 3h written exam (7-step scale), which is divided equally between the 3 main teachers. An excerpt from the 2007 exam can be found in Appendix B.

Aim of the project

The aim of the project is to investigate if there is any correlation between the exam results and the student evaluations on the Plant Biology part (35%) of the Biology A1 course. The outcome of the analysis will then serve as a tool for reflection upon the teaching methods and exam form, with respect to optimizing the learning outcome from the students. In that regard, I will also take a brief look upon the exam set and comment on its current structure.

Methods

Description of the lectures and exercises

In general the lectures consisted of powerpoint presentations, which more or less would function as a monologue, as the students will get a chance to ask questions during the following exercises. However as I also attended the lectures my impression was that the students really liked the lectures and the way the powerpoint "show" was presented.

With respect to the exercises the students were split in 2 groups of approximately 30 students in each. I designed the exercises together with the other instructor who was teaching the other group. We designed the exercises so the students would get around 1h 15min to complete approximately 25 questions, which more or less corresponded to the exam structure where Plant Biology accounts for 1/3 of the 3h written exam. After the students have completed the questions in small groups (with the possibility of getting help), we would then go through the questions by asking the students for the answers. After they have answered (whether or not it was right) I/we would then go through the questions and answer using powerpoint, and discuss why and how they should have been able to get the right answer. I always found the students to be highly motivated, which made it a lot of fun to teach them.

Description of the written exam 2007

The written exam is divided into 3 parts, which are made separately by each of the 3 main responsible teachers – see below. This also influences the development/design of exam questions, which are quite different between the 3 Plant-, Cell and Animal Biology (a copy of the 2007 exam can be found in Appendix B.

The division of the teaching/exam topics on Biology A1:

- 35% - Plant biology and cell division (Jack & Bill)
- 33% - Cell biology and macromolecules (Martin & Zara)
- 33% - Animal biology and cell functions (Daniel)

The Plant biology and cell division part consist of multiple choice questions and pictures in which the students needs to mark certain features, which do not require the students to formulate their understanding of the problem during the problem-solving phase of the test, meaning that this will typically stimulate a "surface learning approach" (Biggs and Tang; 2007). In comparison, both the Cell biology and macromolecules & Animal biology and cell functions are made up of minor or major essay questions, which forces the students to formulate their understanding in sentences thereby stimulating a "deep learning approach" (Biggs and Tang; 2007). For all three parts the exam questions also reflects the exercises, which the students face in connection with the lectures during the course.

Student evaluation schemes

The idea of the evaluation schemes was primarily to ensure feedback to the teachers with respect to the lectures and exercises, but also a few minor details about *e.g.* course home page can be found. The course evaluations can be found in Appendix D.

The evaluation scheme was created independently of this report and I will therefore have to "pull out" the relevant data and present it in a more illustrative fashion.

Practical implementation of the analysis

In order to analyze if there is a correlation between the exam results and the student evaluations, I will start by looking at how well the students did on the Plant Biology part of the course by plotting the result and number of students on a graph for a quick and easy overview. Then I will try to extract the most relevant data from the student evaluations in 3 major parts:

Division of the student evaluations used for the analysis:

- General comments – Specific focus on the Plant Biology part.
- The lectures – Plant Biology compared to Animal and Cell Biology.
- The exercises – Plant Biology compared to Animal and Cell Biology.

Based on the above described analysis I will discuss how the correlation between the exam result and student evaluations can be used as a tool for reflection upon teaching methods and student outcome, and present specific suggestions for how to increases the student outcome in the future.

Results

Grades from the 2007 exam: The Plant Biology part

A total of 76 students took the 2007 exam, based on their results I plotted the number of students and pct. correct answers on a graph for a quick and easy overview (Figure 10.1; the original exam results from the Plant Biology part can be found as an excel sheet on Appendix C).

As seen on Figure 10.1, the students did very well on the Plant Biology part of the 2007 exam and only 20 pct. of the students (15 out of 76 students) had less than 50 pct. correct answers (50 pct. dashed line on Figure 10.1). In comparison, 50 pct. of the students (38 out of 76 students) had 75 pct. or more correct answers – 16 pct. of the students (12 out of 76 students) had 90 pct. or more correct answers.

The x-axis represents the number of students and the y-axis represents pct. correct answers. The dashed lines shows the actual level of correct answers, based on the assumption that in a multiple choice test with 25 questions and 5 possible answers in each test, will mean a default level of 5 correct answers. The data is based upon 76 exam sets.

Student evaluations: General comments

Only 13 of the students filled out the evaluation form meaning that the comments should be taken with some caution as this only represents 17 pct. of the students. However I have tried to screen the evaluations for specific issues that has to do with the Plant Biology part – first the positive and then the negative comments (see below).

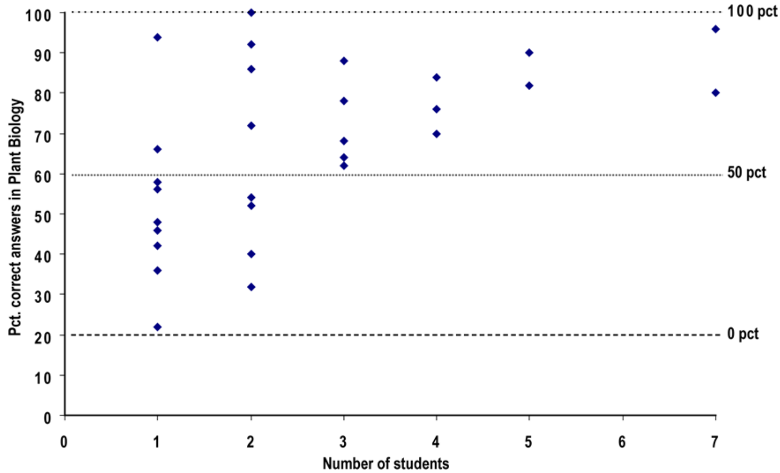

Fig. 10.1. Student scores on the Plant Biology part of the 2007 exam.

Positive comments:

"... Det var godt at få eksempler/paralleller..."
"... Farverige interessante powerpointshows! Det er helt klart et plus!..."
"... Rigtig godt at forelæsningerne forløb ved brugen af et power-point show. Disse har man kunne kigge på senere hen, og så er det også lettere at følge med i forelæsningen, end hvis det foregår med kridt på tavlen. Desuden er det rart at nogle af figurerne fra den læste tekst er med i PP, da man så kunne forholde sig bedre til dem, og forstå det, man ikke havde forstået ved at læse det selv..."
"... Det var godt at det var så nemt at finde en udgave af forelæsningerne til at sætte noter på, og at disse allerede var sat til at have 4 slides per side..."
"... Jeg synes eksaminatorietimerne var rigtigt gode..."
"... Rigtig godt når vi fik udleveret spørgsmålsarkene, og så fik tid til at arbejde dem igennem, for til sidst at gennemgå dem ved tavlen..."
"... Dejligt når spørgsmålene er på PP så man kan se dem der, i stedet for der bliver brugt tid på at skrive dem op på tavlen..."
"... Det fungerede markant bedre når en af forelæserne var med i timerne, eller i plantedelen, hvor der var en anden eksaminatorielærer..."

"…Vi har ikke brugte gruppe formen (kun i første eksaminatorium), hvilket jeg synes er rigtig godt, da man får mere ud af at side med hver enkelt spørgsmål selv…"
"…Det er godt med dias, så man ikke bruger tid på at skulle skrive på tavlen…"
"…Bill with other teachers: Meget positivt at spørgsmålene kunne/skulle besvares unden for meget brug af bogen da dette var med til at forberede til eksamen…"
"…gennemgangen flød bedre hos Bill med de andre lærere da svarene blev sat ud på nettet, og vi ikke behøvede bruge tiden på at skrive ned, men kunne diskutere svarene i stedet…"
"…Alle spørgsmål i eksaminatorietimerne ledte til en dækkende diskussion/gennemgang af materialet…"

Negative comments:

"…Det var ofte svært at nå igennem alle spørgsmålene. Vi brugte meget tid på de første spørgsmål, og måtte derefter gennemgå de sidste alt for hurtigt…"
"…Det var knapt så vellykket, at man først sad og lavede alle opgaverne i grupper, for derefter at gennemgå det med powerpoint styret af en lærer. Dette fik det hele til at 'gå lidt i stå'…"
"…Jeg synes eksamensformen var underlig/vanskelig. Det var svært at finde ud af hvad der ønskes af en…"
"…Jeg synes det havde været bedre at man enten kørte med multiple choice hele vejen igennem, eller at der var færre spørgsmål og man skulle uddybe mere…"
"…Generelt om spørgsmål (eksamen og eksaminatorietimer): De var ikke helt præcist (og enkelt) formulerede og det var ofte svært at gennemskue hvad det egentlig var der var det korrekte svar på spørgsmålet…"
"…Det har været svært at vide hvor meget, og hvor grundigt vi har skullet kunne eksamensstoffet uden ad, det kunne være rart at have en ide om hvordan eksamensniveauet bedømmes, eksempelvis med et besvaret eksamenssæt på nettet med en tilhørende karakter, så man har en ide om hvor meget der er krævet, for nogle af eksamensspørgsmålene lagde op til en overfladisk besvarelse, mens der muligvis var forventet en grundig besvarelse…"

As seen in the above comments the students are in general very pleased with the teaching methods used for Plant Biology, although some find it hard understand the "true" meaning of the questions asked in the exercises/exam. However in order to get a more quantifiable means of analysis of the evaluations I will look more specific on how the students evaluate Plant Biology compared to Animal- and Cell Biology with regards to the teachers, lectures, exercises etc. in the following sections.

Evaluation of the lectures

As part of the evaluation scheme the students were presented with specific questions and were asked to indicate if they thought it was good or bad using a 5 point scale – see below. The average score for each question were then plotted for each of the 3 parts of the course (Plant-, Animal- and Cell Biology), to facilitate a quick and easy analysis of the scores – see Figure 10.2.

The 5 point scale:

- **5**, totally agree
- **4**, agree with some minor disagreements
- **3**, not sure or the question is not relevant
- **2**, disagree
- **1**, totally disagree

As seen on Figure 10.2, the students are in general very positive about the lectures – non of the questions falls below the score of 3. For "The level of the lectures" all 3 parts of the course scores around 4, whereas Plant Biology stand out in the two questions regarding "Are the teachers good at presenting" and "The lectures are understandable" with a score around 4.75, where Animal- and Cell Biology scores around 4 points. For the last questions "The lectures are exciting" both Plant- and Cell Biology scores around 4.5, where Animal Biology scores 4.

The columns represent the 3 different parts of the Biology A1 course (Plant-, Animal- and cell Biology), where the x-axis is the different questions and the y-axis is the average score from the evaluation schemes. The 5 point scale (**5**, totally agree; **4**, agree with some minor disagreements; **3**, not sure or the question is not relevant; **2**, disagree; **1**, totally disagree).

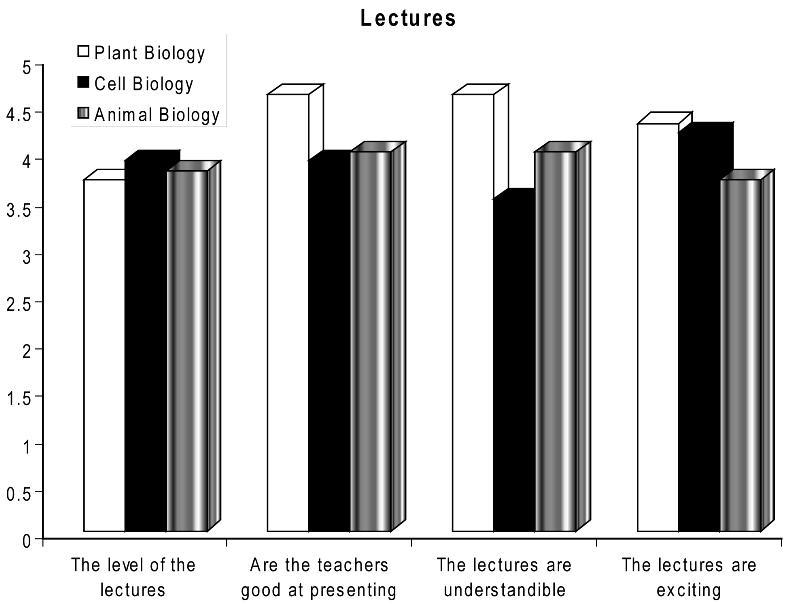

Fig. 10.2. The students evaluation of the lectures

Evaluation of the exercises

As with the evaluation of the lectures the average score for each question regarding the exercises were plotted for each of the 3 parts of the course (Plant-, Animal- and Cell Biology) – see Figure 10.3. The original scores can be found on the evaluations in Appendix C.

With respect to the exercises the students were asked if "The level is to high". Here Plant Biology scored 3.5, whereas both Animal- and Cell Biology scored 4.5 (Figure 10.3), meaning that the students found the level of the Plant Biology exercises at a suitable level whereas they found Animal- and Cell Biology to be at a bit to high level.

When the students were asked if they thought "The outcome is high", all three parts of the course (Plant-, Animal- and Cell Biology) scored around 3-3.5, indicating that the students found the outcome to be on an acceptable level – with room for improvements!

The columns represent the 3 different parts of the Biology A1 course (Plant-, Animal- and cell Biology), where the x-axis is the different ques-

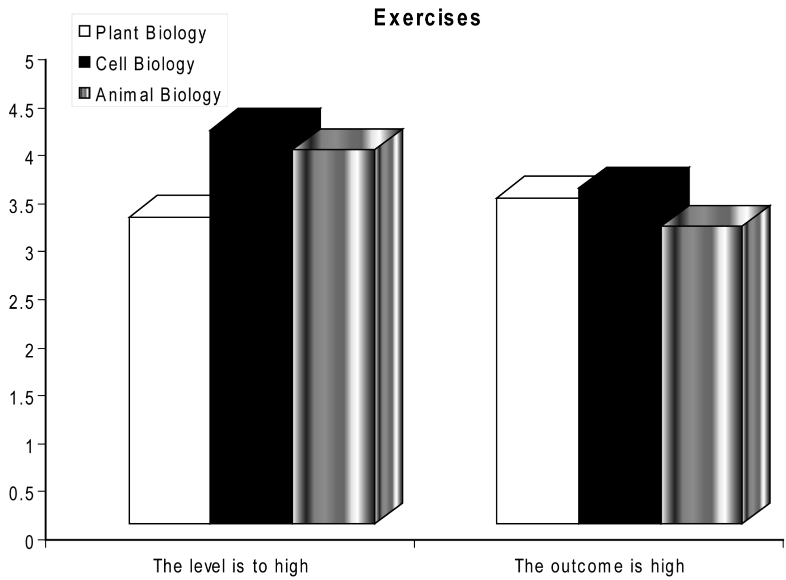

Fig. 10.3. The students evaluation of the exercises

tions and the y-axis is the average score from the evaluation schemes. The 5 point scale (**5**, totally agree; **4**, agree with some minor disagreements; **3**, not sure or the question is not relevant; **2**, disagree; **1**, totally disagree).

Discussion and conclusion

Reflections upon the student evaluations of the lectures

In general it seems that the students are pleased with the lectures for the Plant Biology part of the Biology A1 course. The lectures primarily functions as a monologues from the teacher, however although the students are not "active" during the lectures they still get the basis knowledge needed to follow and actively participate in the exercises, which are always closely aligned with the lectures.

The main reasons that lectures works so well is primarily that the students find the lectures very exciting and relevant, they are kept at a level where the students can understand what is presented, they have easy access to the student material (*e.g.* lectures which they can print out online – more time for listening instead of writing), and not least that the teacher is highly skilled in presenting.

Although, the students scored Plant Biology highest in 3 of the 4 questions asked in the evaluations scheme (figure 10.2), there are still obviously issues that can be improved to ensure a better learning outcome for the students with regards to the lectures as will be discussed in "How to increase 'deep learning' and student outcome".

Reflections upon the student evaluations of the exercises

The students scored the level on Plant Biology to 3.5 in comparison to 4-4.5 for Animal- and Cell Biology, indicating that they found the level suitable for Plant Biology, whereas Animal- and Cell Biology might be considered a bit to high or difficult for the students. With respect to the exercises the students found the outcome to be more or less equal for Plant-, Animal- and Cell Biology, with a score around 3.5 (figure 10.3), which indicate that there is room for improvements for Plant Biology - but also for Animal- and Cell Biology. The students liked the current model in which the questions were discussed at the exercises, that they do the exercises in small groups, and that they have easy access to the student material online*,* which they can print out online a couple of days before the exercises, thereby giving them time to prepare. In addition, both the lectures and exercises are constructed so they reflect the exam situation *e.i.* questions presented as they would be for the exam, which helps the students prepare for the real situation at the "green table" – where most of them achieve a high success rate (only 20 pct. of the students have less than 50 pct. correct answers on the Plant Biology part of the 2007 exam, figure 10.1).

Although there were also negative comments *e.g.* lack of time to finish the last questions, badly formulated sentences, it is therefore no surprise that the students are in general very happy with the teaching methods used for the Plant Biology part of the Biology A1 course. However as with the lectures there are still obviously issues that can be improved to ensure a better learning outcome for the students with regards to the exercises and exam questions as will be discussed in the following section.

How to increase "deep learning" and student outcome

In order to increase student outcome, I would suggest that the teacher(s) should introduce "PBL" in the lectures, clear learning goals for each lecture, as well as minor group assignments, and questions to plenum. Such activities will force the students to participate actively in the lectures and thereby making them take a bigger responsibility for their own learning (Biggs and Tang; 2007).

For the exercises and the exam questions it would be an advantage if the multiple choice questions could be discarded and replaced with assay based questions (as is the case for the Animal- and Cell Biology parts, Appendix B, which will force the students to formulate the answers and thereby increasing their learning abilities – again this will forces them to take a higher degree of responsibility for their own learning. As shown in a study by Scouller and Prosser (1994), multiple choice questions can be a problem for general "surface learners" which will not be stimulated to become deep learners, whereas the general "deep learners" will remain more or less unaffected in their general study strategy.

In addition, to the exercises minor written projects *e.g.* covering the major topics could be introduced and used in order to give the students formative evaluation, which is known to have a positive effect on the learning outcome (Biggs and Tang; 2007), *e.g.* using good feedback as suggested by Nicol and Macfarlane-Dick (2006), which include that the teacher helps to clearly what good performance is, deliver higher quality of information to the students regarding their learning, encourage dialogue around learning, encourages positive motivation and self-esteem etc.

It is also important to increase the course alignment between Plant-, Animal- and Cell Biology, so the teaching structure, exercises and exam questions are more streamed lined. As it is currently, the students don't have the feeling of taking one course, but 3 different independent courses which each have their own teaching methods, and way of formulating questions and evaluating the exam.

The experience I have from the pre-project on KNUD (Gori et al.; 2008) is that if all the issues described above are followed (introducing an active learning environment in both the lectures and exercises). This will motivate the students to become more aware of their own responsibilities in the learning process, which will force them to become "deep learners", meaning a higher learning outcome.

Using student evaluation schemes as a tool for reflection

For this study, student evaluation schemes were chosen as a tool for reflection upon the teaching methods and student outcome for the Plant Biology part of Biology A1. One of the main problems was that the evaluation schemes were not made independently of this analysis and therefore the relevant data had to be “pulled” out of the evaluation schemes. Another problem was that only 13 of the 76 students actually filled out the evaluation form, meaning that the comments dos not necessarily represent the general meaning on the course. To improve this one might consider either making specific evaluations schemes which would fit the analysis and then ensure that “all” the students filled it out and handed it back *e.g.* by introducing it in one of the exercise. Introduction of focus group interviews as described by Klinke and co-workers and references therein (Klinke et al.; 2005) would also be a good way of getting information from the students, although this type of evaluation of course will require extra preparation and students that are willing to participate.

Conclusion

This project has made it clear to me that there is (and will properly always be!) issues that can be improved, even though the students might have a good success rate at the exam and they generally like the teaching methods on the course. Traditional lectures which primarily functions as monologues (more or less) and multiple choice questions for the exercises and exam don’t stimulate “deep learning”, and it is therefore important to introduce PBL, clear learning goals for each lecture, minor exercises (with formative assessment/feedback) and assay questions in order to facilitate a better student outcome. This will also help on the general course alignment so the students will “feel” it as one coherent course instead of 3 minor independent parts.

A Appendix: Biology A1: Course Description

Biologi A1: Cellebiologi - Fra organisme til molekyle

Udgave:	Efterår 2007 NAT
Point:	7,5
Blokstruktur:	1. blok
Skemagruppe:	B
Semester:	1. år, blok 1
Varighed:	7 uger
Omfang:	21 timers forelæsninger og 42 øvesestimer
Institutter:	Institut for Molekylær Biologi
Uddannelsesdel:	Bachelor niveau
Kontaktpersoner:	Martin Berchtold, mabe@my.molbio.ku.dk, 3532 2089
Skema oplysninger:	Vær opmærksom på, at der i kurset findes både forelæsninger og øvelsestimer. Se oplysninger om undervisningstidspunkt for øvelsestimer herunder. Se oplysninger om undervisningstidpunkt for forelæsninger via linket under "tid og sted". Hvilket undervisningshold du er på til øvelsestimerne, vil fremgå på selvbetjeningen på punkt.ku. sidst i uge 34. Til forelæsninger undervises alle studerende sammen. Lectures: Tirsdag 9.00-10.00 på HCØ Aud 1 Tirsdag 13.00-14.00 på HCØ Aud 1 Fredag 9.00-10.00 på HCØ Aud 2 Eksaminatorie: Hold 1: Tirsdag kl. 10-12 på Biocentret i 4-0-32 Tirsdag kl. 14.00-16.00 på Biocentret i 4-0-32 Fredag kl. 10.00-12.00 på Biocentret i 4-0-32 Hold 2: Tirsdag kl. 10.00-12.00 på August Krogh i Aud 3 Tirsdag kl. 14.00-16.00 på Biocentret i 4-0-24 (den 9. oktober på August Krogh i Aud. 3) Fredag kl. 10-12 på August Krogh i Aud 2 (den 28. september er på Biocentret i 1-2-03)
Skema oplysninger:	blok 1 Samlet oversigt over tid og sted for alle kurser inden for Lektionsplan for Det Naturvidenskabelige Fakultet Efterår 2007 NAT
Formål:	Det samlede formål for de to Biologi A kurser (A1 og A2) er at give en introduktion til principper og centrale emner inden for moderne biologi herunder en indføring i levende organismers form og funktion, cellebiologi, molekylærbiologi og genetik. Kurserne sigter desuden på at give studenten et basalt biologisk og biokemisk begrebsapparat, der skal muliggøre det senere arbejde med biokemiske og biologiske problemstillinger under biokemistudiet.
Indhold:	Biologi A1 kurset vil være fokuseret på organismers (planters og dyrs) grundlæggende anatomi og fysiologi og deres organer, væv, cellers grundlæggende struktur og funktion, på organeller og membraner, på cellecyklus og celledeling samt makromolekylers opbygning.
Målbeskrivelse:	1. Studenten skal opnå en forståelse af de nedenfor skitserede emner på niveau med det anbefalede kursusmateriale. Studenten skal kunne demonstrere denne forståelse ved opgaveløsning blandt andet ved hjælp af illustrationer. 2. Kunne beskrive tilpasning af dyr og planters anatomi og fysiologi til miljø og fysiske udfordringer/love. Kunne beskrive konvergent evolution og hvordan specifikke tilpasninger belyser evolutionsprocessen

	3. Kunne beskrive den hierakiske opbygning af liv – makromolekyler/organeller/celletype/væv/organ/organsystem. 4. Kunne beskrive homeostase i biologiske systemer via feedbacksystemer og intercellulær kommunikation, herunder hvordan dyr og planter responderer på ændringer i miljøet. 5. Studenten skal opnå et biologisk og biokemisk begrebsapparat på et niveau så studenten kan forstå og redegøre for centrale emner indenfor ernæring, cellulær respiration, fotosyntese, kredsløb, gastransport, osmoregulering, mitose, meiose, cellulær kommunikation, celle cyklus og reproduktion. 6. Studenten skal være i stand til at forklare måder, hvorpå planter påvirker menneskers liv. 7. Studenten skal være i stand til at forklare hvordan planter udvikler sig (plasticitet, samt determineret og ikke-determineret vækst). 8. Studenten skal være i stand til at vurdere og koordinere viden fra de forskellige emner gennemgået i kurset.
Lærebøger:	Campbell/Reece, 7th edition
Tilmelding:	Studerende optaget på biokemi september 2007 er automatisk tilmeldt kurset For studerende optaget før september 2007 er der kursustilmelding på selvbetjeningen i perioden 1-10. juni 2007.
Eksamensform:	3 timers skriftlig eksamen uden hjælpemidler. Intern censur. karakter efter den 7 trin skalaen
Eksamen:	Skriftlig prøve den 2. november 2007. Reeksamen: Skriftlig prøve den 1. februar 2008.
Kursus hjemmeside:	Kursushjemmesiden administreres af: Se liste
Bemærkninger:	Kan være på dansk, hvis ingen udenlandske studerende er tilmeldt.
Undervisnings sprog:	Engelsk
Sidst redigeret:	19/9-2007

B Appendix: Example of exam questions

Besvarelsen ønskes på opgavesættet.

13. Celle cyklus består af flere forskellige faser. Disse faser foregår altid i samme rækkefølge. Hvilken en af nedenståenden udsagn er rigtig?

1) G1;G2;S;M
2) G1;S;G2;M
3) G0;G1;G2;S
4) M;G2;S;G1
5) M;G2;G1;S

14. M fasen I mitosen er opdelt I flere forskellige faser. Disse faser foregår altid I den samme rækkefølge. Hvilken en af nedenstående udsagn er rigtig?

1) Prophase; Prometaphase; Metaphase; Anaphase; Telophase og Cytokinesis
2) Prophase; Metaphase; Prometaphase; Anaphase; Telophase og Cytokinesis
3) Prophase; Prometaphase; Anaphase; Metaphase; Telophase og Cytokinesis
4) Metaphase; Prophase; Prometaphase; Anaphase; Telophase og Cytokinesis
5) Prometaphase; Prophase; Metaphase; Anaphase; Telophase og Cytokinesis

15. I løbet af cellecyklus fasthæfter spindle microtubules til chromatiderne i strukture kaldet?

1) Kinetochores
2) Centrochores
3) Centromeres
4) Centrosomes
5) Spindle bodies

16. Mitosen er ens i både planter og dyrceller, men planteceller skal også danne en ny cellevæg. Dannelsen af denne cellevæg starter med produktionen af en struktur der hedder?

1) Cell plate
2) Mitotic plate
3) Wall plate
4) Cytokinetic plate
5) Wall spindle

C Appendix: Exam results from Plant Biology

Eksamens	Antal rigti(	l pct.
1	21	84
2		
3	10.5	42
4	17.5	70
5	19	76
6		
7	18	72
8	19	76
9		
10		
11	17	68
12	22.5	90
13	22	88
14	14.5	58
15		
16	10	40
17	17.5	70
18	20	80
19	19	76
20	17	68
21	16.5	66
22		
23	22	88
24	12	48
25	10	40
26	19	76
27		
28	24	96
29	20	80
30	20.5	82
31	17.5	70
32	20.5	82
33	22.5	90
34	19.5	78
35	16	64
36	15.5	62
37	25	100
38	19.5	78
39	24	96
40		
41	14	56
42	20	80
43	5.5	22
44	20.5	82
45	11.5	46
46	13.5	54
47	22.5	90
48	24	96
49	15.5	62
50	22	88
51		

Eksamens	Antal rigti(	l pct.
52	17.5	70
53	18	72
54	23	92
55	25	100
56		
57	20.5	82
58	22.5	90
59	13	52
60		
61	24	96
62	21	84
63	23	92
64	20	80
65	20.5	82
66	17	68
67	24	96
68	8	32
69		
70		
71	19	76
72		
73	21.5	86
74	22.5	90
75		
76	20	80
77	21.5	86
78	15.5	62
79	23.5	94
80	21	84
81	24	96
82		
83		
84	20	80
85	9	36
86	13.5	54
87	16	64
88	24	96
89	21	84
90	13	52
91	20	80
92	16	64
93	19.5	78
94	8	32

Eksamen i Biiologi A1 for Biokemistuderende
Fredag den 2. november 2007
Eksaminator: William George Tycho Willats
Del 1 (vægt 35%)

D Appendix: Course evaluation scheme

Evaluering af Biologi A1

Undervisning i blok 1, efteråret 2007

Formålet med evalueringen er først og fremmest at give underviserne feedback på deres undervisning. Din besvarelse af skemaet vil ikke nødvendigvis få betydning for dig selv, men vil være af betydning for underviserne - og for de fremtidige studerende. Vi beder dig derfor om at forholde dig nøgternt til besvarelsen og prøve at se bort fra personlige sym- eller antipatier.

Såfremt du har deltaget for lidt i undervisningen til på et rimeligt grundlag at kunne besvare skemaet, bedes du sætte kryds her og undlade at udfylde skemaet.

[ ] Jeg har ikke deltaget tilstrækkeligt i undervisningen til på et rimeligt grundlag at kunne besvare skemaet.

Når der angives svarmulighederne 5 til 1 udfyldes skemaet ved at sætte en ring rundt om tallet der svarer til det udsagn, der mest præcist giver udtryk for dit synspunkt. Du er selvfølgelig velkommen til at skrive kommentarer i forbindelse med alle spørgsmål.

5 betyder at du er helt enig
4 betyder at du er enig med forbehold
3 betyder at du ikke er sikker, eller at udsagnet ikke er relevant
2 betyder at du er uenig
1 betyder at du er helt uenig

GENERELT

Undervisning på dette kursus forløber hovedsageligt top-down, men med introduktion af makromolekyler i midten af kurset. Hensigten hermed er give et biologisk overblik i starten og herefter gå mere i detaljen for at se hvordan forskellige organismer er tilpasset strukturelt, og fysiologisk.

1	Top-down forløbet er fordelagtigt		5	4	**3**	2	1
2	Vi har fokuseret på de rigtige emner i undervisningen		5	**4**	3	2	1

FORELÆSNINGER

3	Antallet af forelæsningstimer er højt		5	4	**3**	2	1
4	Sværhedsgraden/niveauet af forelæsningerne er højt	Bill	5	**4**	3	2	1
		Martin	5	**4**	3	2	1
		Daniel	5	**4**	3	2	1
5	Forelæserne er gode til at formidle stoffet	Bill	**5**	4	3	2	1
		Martin	5	**4**	3	2	1
		Daniel	5	**4**	3	2	1
6	Forelæsninger er nemme at forstå	Bill	**5**	4	3	2	1
		Martin	5	**4**	3	2	1
		Daniel	5	4	**3**	2	1
7	Forelæsningerne er spændende	Bill	**5**	4	3	2	1
		Martin	**5**	4	3	2	1
		Daniel	5	4	**3**	2	1
8	Forelæsningerne går meget udenfor pensum	Bill	5	4	3	**2**	1
		Martin	5	**4**	3	2	1
		Daniel	5	**4**	3	2	1

9 Hvad var godt/ikke godt ved forelæsningerne – andre kommentarer?

Det var godt at få eksempler/paralleller! Der kan arbejdes på formidlingen i Daniels forelæsninger. De blev nemt for monotone hvilket fik mig til at miste fokus. Til gengæld var forelæsninger generelt præget af farverige interessante powerpointshows! Det er helt klart et plus!

EKSAMINATORIER

10 Antallet af eksaminatorietimer er højt		5	4	**3**	2	1
11 Sværhedsgraden/niveauet af eksaminatorierne er højt	Zara	**5**	4	3	2	1
	Sofia	5	**4**	3	2	1
	Bill with other teachers	5	4	3	**2**	1
12 Udbyttet af eksaminatorietimerne er højt	Zara	5	4	**3**	2	1
	Sofia	5	4	**3**	2	1
	Bill with other teachers	5	4	3	**2**	1
13 Eksaminatorieformen med gruppernes præsentation ved tavlen er en god måde at sætte sig ind i stoffet på og formidle til de øvrige		**5**	4	3	2	1

14 Hvad var godt/ikke godt ved eksaminatorierne – andre kommentarer?

Der var højt engagement fra Zara hvilket var motiverende! Og hun var god mod os på de onde onsdage☺(kage)
Til gengæld havde hun engang imellem svært ved at være på samme niveau som mig – hendes sprog var tit for kompliceret til at jeg forstod det. Hun var god til at stille spørgsmål og få uddybet mange ting – til gengæld afbrød hun tit folk inden de havde svaret færdigt.
Jeg fik aldrig rigtig noget indtryk af den anden lære. Han virkede lidt umotiveret!

15 Hvis du ikke deltog i eksaminatorierne var det så på grund af eksaminatorieformen – forklar gerne?

UNDERVISNINGSMATERIALE OG KURSUSHJEMMESIDE

16 Det er fordelagtigt at powerpoint præsentationerne er tilgængelige på nettet	**5**	4	3	2	1
17 Det fungerer fint at hente opgaver og forelæsninger fra kursushjemmesiden	5	**4**	3	2	1

18 Har du kommentarer vedr. kursushjemmesiden

Det ville være rart at have powerpoints liggende både i pdf format og powerpoint format

ØVRIGE KOMMENTARER

19 I dette kursus er det altid nemt at finde ud af, hvilke forventninger der er til ens arbejdsindsats	5	4	3	**2**	1
20 Underviseren på dette kursus motiverer de studerende til at gøre deres bedste	5	4	3	**2**	1

21	Arbejdsbyrden i dette kursus er for stor	5	4	**<u>3</u>**	2	1
22	Underviseren bestræber sig virkelig på at forstå de vanskeligheder, de studerende kan have med stoffet	5	**<u>4</u>**	3	2	1
23	Underviseren anstrenger sig virkelig for at gøre emnerne interessante for de studerende	5	4	3	**<u>2</u>**	1

24 Har du kommentarer til undervisningslokalerne? – *de var fine*

25 Har du andre kommentarer til Biologi A1? – *jeg synes eksamensformen var underlig/vanskelig. Det var svært at finde ud af hvad der ønskes af en. Jeg synes det havde været bedre at man entet kørte med multiple choice hele vejen igennem, eller at der var færre spørgsmål og man skulle uddybe mere. Generelt om spørgsmål (eksamen og eksaminatorietimer): De var ikke helt præcist (og enkelt) formulerede og det var ofte svært at gennemskue hvad det egentlig var der var det korrekte svar på spørgsmålet. – dog skal det siges at alle spørgsmål i eksaminatorietimerne ledte til en dækkende diskussion/gennemgang af materialet(måske netop når de var uspecifikke).*

11

How to utilise interdisciplinary backgrounds

Nana Quistgaard

Department of Science Education, SCIENCE,University of Copenhagen

Introduction

Some university courses are aimed at students with differing academic backgrounds. I teach in such a course named Science Communication targeted for students at the Faculty of Science at the University of Copenhagen. The purpose of the course is to provide the students with tools to communicate their particular field of science to layman. The variation in student background constitutes a factor necessary to take into consideration because the nature of the different scientific fields hold by the students such as biology, computer science, nano science, physics, geology, math, and so forth is very diverse. The course has been run twice but the issue of varied scientific backgrounds has not yet been addressed. The purpose of this project is to shed light on the implications of the issue of interdisciplinary backgrounds in order to improve the course.

The focus of the project is based on a previous project I was part of concerned with the implications of interdisciplinary backgrounds in relation to the course Environmental Impact Assessment run by the Faculty of Life Sciences. In this project we investigated the hypotheses that 1) there is a correlation between students' academic background and their perception and impact of the course and 2) student discussions will benefit from interdisciplinary backgrounds in terms of higher impact of the course. We concluded that students' interdisciplinary backgrounds seemed to be an advantage in group discussions. The students thought it was beneficial to the discussions that the different participants were able to contribute with each their perspective based on their specific background. Further, it appeared that students would like the teachers to address the interdisciplinary backgrounds by reminding and encouraging everyone to bring in their specific perspectives to the discussions. Regarding the correlation between academic background and perception/impact, the results were a little vague. But there was a tendency toward a positive correlation; the course appeared to be easier to understand and follow to certain types of students as opposed to others.

The conclusions of the project raised the questions of how to better take into account and utilise the different backgrounds of the students. *How can we as teachers design the course and teach so that the different academic backgrounds of the students can be put into play and utilised? Which tools are at hand?*

Thus, these questions form the basis of the current project concerning the Science Communication Course. The main focus is to further investigate the conclusion regarding the advantage of interdisciplinary backgrounds and, if this conclusion proves plausible, to take a closer look at how I and my co-teachers can address the interdisciplinary backgrounds better and utilise the students' specific backgrounds in group discussions and group work. The outcome would be to conclude on which tools could scaffold the students in how to use their backgrounds.

The approach was to investigate two groups of students who have previously participated in the Science Communication Course. The two times the course has been run the approach to the composition of groups differed. Much of the work carried out by the students is group work such as solving tasks together, making projects, and discussing problems. In the first run the compulsory groups were composed in such a way that the academic backgrounds of the students were as uniform as possible; resulting in biologists in one group, nano scientist in another, computer scientists in a third, and so forth. In the second run, this approach was changed and all groups were composed to represent a mix of the participating students.

Methodology

Focus group interviews were selected as an appropriate interview method to assess the intended purpose. Six students from each of the two rounds of the course were recruited via email-invitations. I had to encourage the students several time to participate in the interview. Finally six students from each round volunteered. This approach meant that the span in the participants' academic backgrounds were not as varied as I could have hoped for though it was varied enough to generate meaningful data. Four different backgrounds were represented in each group which I considered sufficient.

The development of an interview guide for the two focus group interviews was inspired by McCracken's (1988) *grand-tour* questions. These are initiating questions aimed to trigger or prompt the informants in order to promote discussion. The idea is to allow the informants to tell their own story and for the researcher to keep a low profile. Questions should be asked in general and open terms. Grand-tour questions can be supplemented by *floating prompts*, which are used to make the informants specify or elaborate, e.g.: "what do you mean by that?". It is important not to put words into the mouth of the informants for instance by saying: "do you mean that xxx?". Floating prompts arise in the situation and so these are not prepared questions that must be posed. On the contrary, *planned prompts* are questions that are essential to the interview purpose and accordingly must be posed at some point or another. Thus, planned prompts are prepared questions but they should not be posed until the end of a grand-tour sequence if the informants have not touched upon the topics in question already. A possible strategy for the planned prompts is to encourage the informants to recall certain episodes or elements and if needed to show objects, pictures etc. to stimulate the recollection.

Further, I studied the official evaluation of the course consisting of questionnaires in order to identify possible target subjects or problems relevant to the project purpose. Based on this analysis and the overall focus of the project eight grand-tour questions emerged. The first and second respectively regard the students' perception of academic level of the course and their expectations to the course. The third concerns the students' perception of the different elements of the course, such as plenum teaching, discussion sessions, group work, presentations, and feedback sessions. The forth grand-tour question concerns the students' perception/impact of teaching material. The course literature consists of a compendium compiled of text book material and research papers plus a practical oriented booklet. The fifth question regards the relationship between personal effort and impact/understanding of the course. The last three questions aim directly at addressing whether academic background correlates with perception/impact of the course and of the different elements such as group work and discussions. The reason for keeping this direct addressing for the finale part of the interviews was to ensure that the informants would not realize my agenda, which could cause a bias.

The focus group interviews were conducted as one-hour interviews based on the developed interview guide containing the grand-tour questions. The full interview has been recorded for analysis and the recordings have been transcribed. The analysis approach is hermeneutic and *ad hoc* based on (Kvale; 1997). This means that no standard methods are used for analysis but rather a free use of different techniques. The first listening has given a first impression of the interview as a whole. The next step was to go back to specific passages crucial to the purpose. Then I have counted utterances pointing in the same direction thereby looking for patterns and related those to the interview as a whole to verify if they seemed meaningful. Further, I have looked for contrasting and comparable utterances and again related those to the whole. Finally I have built a coherent understanding of the interview data and based the conclusions on that.

Findings

As mentioned, the six participating informants in each interview represent different academic backgrounds. Below follows a list of each of the informants' backgrounds. The names are made up for anonymity.

The students from Round One, interview 1:

- Susi, biology
- Ruth, nano science
- Ole, nano science
- Niels, nano science
- Lars, computer science
- Henrik, molecular biomedicine

The students from Round Two, interview 2:

- Dorthe, geology
- Sofie, biology
- Hans, computer science
- Jesper, computer science

Further two students from nano science and biology respectively had been recruited for interview 2 but one cancelled in the last minute and the other one never showed up.

Correlation between academic background and perception/impact

The tentative conclusion from the previous project mentioned earlier regarding the tendency towards a positive correlation between academic background and perception/impact of the course is not confirmed in this project. The students from Round One predominately agreed in most of there statements. Two particular statements were heavily agreed upon from this interview. One regarded the teaching form during plenum sessions. Three students unambiguously thought the plenum sessions were too full of interruptions such as buzz meetings and questions and that such exercises should be kept for non-plenum sessions (like exercise classes). Two of these students were from nano science (Niels and Ruth) and the third from molecular biomedicine (Henrik). The biology student (Susi) and the third nano science student (Ole) agreed on this and elaborated that if the teacher should ask questions like: "what do *you* think about this?", the students would need to have much more input from the teacher to base there answers on. Otherwise the students' responses would be (and was in their opinion) unqualified talk. The same nano science student who agreed to this (Ole) further uttered though, that the idea of having these buzz meetings was a good because it permitted the students to discuss with the students next to them. In his opinion this worked quite well some of the times so he wasn't all reluctant toward buzz meetings. But this was clearly in opposition to his fellow nano students (Niels and Ruth) and thereby clear conclusions of a correlation between academic background and perception/impact can not be made. The other heavily-agreed-upon statement from Round One regarded the course literature. The majority of the Round-One students' thought the literature was un-concise, too humanistic, and not consistent with the teaching. There were deviations from this viewpoint (that the literature wasn't all bad) but a consistency in which types of students says what can not be traced.

The students from Round Two differ from the students from Round One by being more negative towards the course as a whole. Three of the students (Hans, Jesper, and Dorthe) felt that the course was either difficult, disappointing or that something was missing. It was not only the compendium and the teaching form that were disappointing (as for the students of Round One), but also the topics and whole focus of the course. On the contrary the fourth student (Sofie) was very positive. She thought the course had been very rewarding. Two of the negative students, Hans and Jesper, are both in computer science and this could express a trend but the third negative student (Dorthe) and the positive student (Sofie) are more closely related background-wise than either of them are with Hans and Jesper. This points to other factors for variation than academic background, which is supported by an utterance from Hans saying that he believes perception and outcome relates to expectation of the course. It appears that he, Jesper, and Dorthe expected something else than what the course was, whereas Sofie expected exactly what it was.

The value of interdisciplinary backgrounds

Regarding the second hypothesis from the previous project mentioned earlier that student discussions will benefit from interdisciplinary backgrounds the current project confirms the conclusions made previously; indeed students express to feel that varied academic background are an advantage to the discussions, to group work, and to the overall outcome of the course.

The students from Round One; the ones that were deliberately grouped in mono-background working groups, univocally express that during plenum and exercise class where a span of backgrounds were represented the different viewpoints that were uttered by the different students were very meaningful and rewarding to them. Though most of their group work took place in mono-background groups some of them had participated shortly in group work with students from other subjects than their own and these group works were considered more interesting and fruitful than mono-background group work. A typical perception was that the fellow students with differing backgrounds brought in angles they had not considered themselves and that this was very educational. E.g. Henrik said:

> "Angles came in that I hadn't even considered. For instance, some of the things the computer scientist guys talked about, I hadn't even seen - thought about – that maybe there were other aspects within science – and a whole different way of thinking."

One student specifically said that in the mono-background groups the lack of "other" angles and viewpoints was a shortcoming. Further perceptions were that is was funny and educational to have to craft one's language to be understandable to the others and that it was insightful to learn which words of one's own professional vocabulary were not common words by others, e.g.:

> "And you also become aware about which words you use yourself and that you think everybody understands. Suddenly it occurs to you that it is totally within you own circles [professional wise] that people understand. So in that way it was good to become aware of things you think everybody knows" (Ruth)

The students from Round Two are very much in line with the students from Round One. They were at all times grouped heterogeneously and they all thought that the varied span of backgrounds were beneficial. E.g. they uttered that it was refreshing to meet students from other subjects and that it was funny and educational to observe and experience the different viewpoints of the others. E.g.:

> "I thought it was refreshing for once to meet students from the other subjects around here. It has been very one-sided in the other classes we've had" (Hans)

> "You end up becoming very subject-chauvinistic. It was fun to become inspired by the other's ideas and examples" (Sofie)

> "It was fun just to observe and hear the different approaches people have – and real eye-opener" (Dorthe)

The only exception to this view of appreciating interdisciplinary backgrounds was uttered by Dorthe stating that she thought this one particular group work activity possibly would be more fruitful if the groups were of mono-backgrounds: "*maybe the part on museum communication would have been better off with mono-background groups*". A response to this was made by Hans who disagreed: "*then I would say that in a group of computer scientist guys having to make a museum exhibit it would not have worked*".

In conclusion this project shows that (1) there is no clear correlation between academic background and perception/impact of the course in Science Communication and (2) discussions and group work clearly benefits from interdisciplinary backgrounds and this regards all of the different activities of the course. There was no clear consensus that particularly activities of the course would be better off with mono-background groups. In the following section I will investigate how the teaching of the course can be crafted so that the different academic backgrounds of the students can be better put into play and utilised. I will base the investigation on the students own ideas (apparent from the interviews) and discuss those.

How to utilise interdisciplinary backgrounds

Three main ideas emerged from the interviews. The first is to specifically address the different backgrounds in plenum or during exercise class. This could be done in various ways, when discussing a particularly topic, e.g. a biology-related topic. For instance, the teacher could encourage all of the expert students (in this case the biology students) to comment on the work presented by the different groups excluding their own. Also, the teacher could encourage a sort of battle between the different groups of students when discussing e.g. a biology-related communication product or issue by specifically asking the computer science students, the biology students, the nano science students etc. what they think of this product or issue and why.

I believe this idea could successfully utilise the various backgrounds represented and further facilitate an intrinsic motivation among the students, since this approach encourage each of them to bring in their existing competencies and talk about something they already have an interest in and know something about (Biggs and Tang; 2007, p. 31). Possibly such experiences could have a positive feedback and stimulate even further intrinsic motivation towards the unfamiliar field of communication.

The second main idea that emerged from the interviews is to develop tasks for group work that holds interdisciplinary possibilities. Thus, each task should contain some biology, some computer science, some nano science, some geography etc. thereby enabling the group to approach the task from different angles. This should allow the students to contribute with their particular expertise and also to force them to involve with other fields than their own. Like the previous idea this idea could possibly facilitate or increase an intrinsic motivation by encouraging the students to bring in their specific expertise.

The third main idea that emerged from the interviews is to form groups of two students with different backgrounds and give them the task to each make an article based on an interview with the other about his or hers particularly field. This idea could enable the interviewing student to practice the interview-method and the interviewee to practice how the phrase and angle ones own topic when communicating with layman. Both of these activities are part of the ILOs of the course and at the same time utilises the varied academic backgrounds.

Also evident from the interviews is the statement that the buzz meetings is a bad idea in plenum as described above. These statements are not in agreement with current views of teaching, where plenum lessons are not seen as one-way communication but should incorporate interactivity such as buzz meetings (Herskin; 2001). This discordance could reflect that students don't always know what is best for them, but may very well be worth taking a closer look at. Based on these findings I will investigate the student's statement further to see if this count for the majority and if so look into alternative approaches. One option is to provide the students with more information before demanding of them to discuss and have their own opinion. This is in line with what some of the students in this project expressed.

Closing comments

In conclusion I believe that all of these ideas are realistic and will contribute to improve the course in Science Communication. Further, this project has shown how much valuable information can be gained from focus group interviews. I have learned that especially when developing a new course focus group interviews can contribute in the adjusting of the course during the first two-four times the course is run.

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Fra øjebliksbillede til proces – i Patobiologi

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Indledning

I 3. blok (forår) 2009 har jeg undervist på kurset "Patobiologisk basiskursus" på LIFE. Kurset henvender sig til 2. års studerende på dyrlægestudiets bachelordel. Det strækker sig over blokkens første 8 uger og består af 3 forelæsninger ugentligt (80 min.), efterfulgt af 80 min. øvelsesundervisning, 2 af de 3 ugentlige undervisningsdage.

I kurset deltager hele årgangen af veterinærstuderende samlet, dvs. ca. 200 studerende. I øvelsesundervisningen er de studerende delt op på to mikroskopiundervisningssale med hver 90 -100 studerende pr. underviser. Indtil nu har vi startet øvelsesundervisningen med at gennemgå 3 - 4 histologiske præparater (dvs. tynde skiver af organer fra syge dyr) ved et master mikroskop med et AV-udstyr der transmitteres til begge sale, hvori der er opstillet en skærm for hver 6 studerende.

Efter gennemgangen har de studerende ca. en time pr. gang til at sidde ved deres eget mikroskop, hvor de kan tage de snit i præparatkassen, der lige er gennemgået og genfinde de morfologiske strukturer og forandringer. Det kommer ofte primært til at dreje sig om at genfinde forandringerne, men det er en oplagt lejlighed til at sætte det sete ind i et større patobiologisk perspektiv.

Målsætning

Mine mål med dette KNUD-projekt har været:

- at afklare om manglen på tid til at studere har sat sig spor således, at de studerende prioriterer et "surface approach" til indlæring og dermed har sværere ved at svare på spørgsmål, der forudsætter en dyberegående forståelse af stoffet. Til dette forstudie vil jeg anvende det ordinære eksamenssæt fra april 2009.
- at undersøge hvilke TLA og ændringer i øvelsesundervisningen de studerende selv mener kan stimulere/understøtte en indlæringsstrategi, som fører til en dybere forståelse af pensum og hvilke dele af undervisningen vi ikke bør ændre på, hvis det er op til de studerende. I den sammenhæng har jeg gennemført et fokusgruppeinterview med 3 studerende og jeg betegner i det efterfølgende denne del som hovedstudiet.
- at komme med forslag til hvordan man kan ændre undervisningen så den faciliterer et "deep-learning approch", baseret på fokusgruppens forslag, krydret med egne refleksioner.

Forstudie:

Observationer:

Har vi nogen problemer? Umiddelbart synes der ikke at være de store pædagogiske problemer i kurset. De studerende er yderst tilfredse jvf. kursusevalueringen, udarbejdet af 164 ud af de 194 studerende der fulgte kurset. Over 90 % af evalueringsbesvarelserne var enten enig eller helt enig i at kurset samlet set var godt. Underviserne betegnes som både kompetente og dygtige til at formidle stoffet, 86 % af besvarelserne giver udtryk for at vi har ramt det faglige niveau fint, og flere har efter eksamen, i mails, givet udtryk for at vores eksamensspørgsmål var både fair og lå i fin forlængelse af undervisningen uden ubehagelige overraskelser.

Et gennemgående tema var dog en kritik af lærebogen, som vi har taget til os og den skiftes ud fra næste sæson. Men et er studentertilfredshed, et andet er om vi opnåede det vi ville med undervisningen, – om de beskrevne kompetencer, intented learning objectives (ILO), rent faktisk er blevet nået. I kompetencebeskrivelsen står der bla. at de studerende skal kunne:

- a: Anvende den rette terminologi til at beskrive og redegøre for patologiske manifestationer på såvel det mikroskopiske som det makroskopiske niveau, samt kunne b: beskrive de tilgrundliggende molekylære og cellulære mekanismer, som ligger til grund for de patologiske manifestationer (ILO1a og b).

- Erhverve sig et fagsprog med henblik på at kunne diskutere i, med og om patobiologi med såvel fag-kolleger som lægmand (ILO2).

Det er min opfattelse, at de studerende i høj grad er underlagt et tidspres og jeg blev opmærksom på, at en del af årgangen formentlig antog et "surface approach" for at nå at komme stoffet igennem. Ville det være muligt gennem en analyse af eksamensbesvarelserne at be- eller afkræfte denne fornemmelse?

Årets eksamensopgavesæt havde spørgsmål, der testede såvel brug af fagterminologi (ILO1a), som hvorvidt de studerende havde en dybere forståelse af de patobiologiske processer (ILO1b). Ud fra min opfattelse af, at de studerende i høj grad følte sig tvunget til at antage et "surface approach" opstillede jeg følgende hypoteser:

- at ILO2 ikke oplevedes som direkte mål for de studerende og kun blev udfyldt i det omfang de tjente til at opnå ILO1.
- at hovedparten af de studerende fokuserede på at kunne svare på spørgsmål der opfyldt ILO1a og
- at færre ville kunne svare fyldestgørende på spørgsmål, som forudsatte et "deep learning approach".

Metode i forstudiet:

Jeg satte mig for at undersøge, hvilke eksamensopgaver/spørgsmål de studerende havde klaret godt og hvilke de havde klaret dårligst i ved eksamen april 2009.

Jeg udregnede for alle besvarelserne til eksamensspørgsmålene en værdi jeg kaldte %-point (antal opnåede point af max. mulige i %) for den enkelte opgave. Herefter udregnedes medianen og gennemsnittet for alle de studerende (n=196) svarende til hvert enkelt eksamensspørgmål.

Hypotesen var: at de opgaver der fordrede en dybere forståelse af stoffet ville være ringere besvaret end de der kunne besvares ud fra et "surface approach".

Hvis det viste sig at være tilfældet, kunne en mulig tolkning være at det afspejlede en mangel på "deep learning". Et forhold vi trods den "gode" evaluering i så fald ville være nødt til at opfatte som en pædagogisk udfordring.

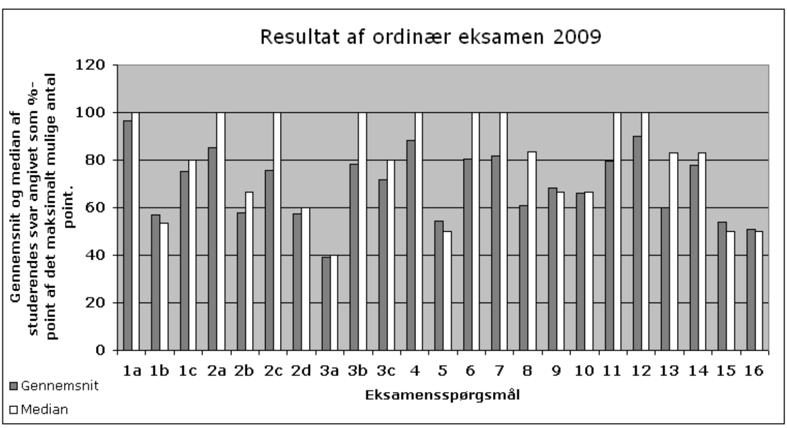
Der blev stillet 3 hovedspørgsmål, som var underopdelt i a,b,c... og 13 bi-spørgsmål.

Jeg valgte at definere et “let” spørgsmål som et, hvor medianen på %-point var 100 og gennemsnittet af de studerendes besvarelse var nær 90 (forstået som 90 % af maximalt opnåelige point for den stillede opgave).

“Svære” spørgsmål var tilsvarende defineret som spørgsmål, hvor median-besvarelsen var nede på 50, og gennemsnittet af %-point tilsvarende lå på ca. 50 (svarende til at både gennemsnittet for årgangen og medianen lå på en besvarelse der gav 50 % af de max. mulige point i den stillede opgave).

Resultater af forstudiet:

De “lette” spørgsmål i eksamenssættet var tilsyneladende nr. (jf. figur 12.1):
1a: Nævn de 5 kardinalpunkter for den akutte inflammation
2a: Definer begrebet infarkt
4: Hvad menes der med kernepyknose? Hvornår ses denne forandring af kernen?
12: Nævn 3 tilstande der disponerer til trombe-dannelse



Figur 12.1. Eksamensresultater 2009

De “svære” spørgsmål nr.:
1b: Giv en kort redegørelse for mekanismen bag fremkomst af hvert af disse kardinalpunkter.

3a: En hund bringes til din dyrlæge klinik. Ejeren har observeret en “svulst” (tumor) på bugen af hunden. Beskriv hvilke overvejelser du gør dig vedrørende makroskopisk skelnen mellem benign og malign neoplasme.
5: I den akutte inflammation kan der i visse tilfælde ses fibrinøst exudat. Hvad består det af og hvordan dannes det?
15: Hvad forstås ved begreberne: Protoonkogen Onkogen Tumor suppressor gen?
16: Nævn de 6 “Hallmarks of Cancer”

Analyse/Diskussion

Der syntes således at være det fællestræk for de “lette” opgaver at de var indledt med verberne “definér”, “nævn” eller “forklar hvad ordet betyder”.

Den viden det kræver for at besvare disse spørgsmål behøver i sagen natur ikke at være særlig “dyb” eller reflekteret. Omvendt kan begrebsmæssig paratviden ikke undværes i et fag som vores. Da vi som målsætning har, at de studerende skal tilegne sig det patobiologiske sprog, som de sidenhen skal kunne manøvrere i, har vi en forpligtelse til at undervise og teste dem i denne kunnen. Dette forhold afspejler sig i at nogle spørgsmål har paratvidenskarakter.

At de svære spørgsmål var svære afspejler formentlig, at de fordrer en dybere forståelse af de patobiologiske mekanismer, dvs. af patobiologien som en viden om sygdomsprocesser. Spørgsmål 3a er anderledes end de øvrige i det det forudsætter at de studerende kan anvende deres viden om processer i en praktisk situation, hvorpå de skal kunne drage slutninger baseret på denne viden.

Hovedstudiet

Problemstilling

Det følger af resultaterne fra forstudiet, at der hos nogle (men langt fra alle) studerende synes at være en tendens til “surface” indlæring. Hvis man ønsker, at de studerende ved kursets afslutning kan anvende de patologiske begreber nuanceret og dermed blive i stand til at diskutere patologiske problemstillinger, bliver vi nødt til at tilrettelægge undervisningen, så de bibringes denne kunnen.

Med 200 studerende, som er hårdt spændt for og relativt få lærekræfter, er det min vurdering at en indsats i forbindelse med øvelsesundervisningen ville kunne bidrage bedst til løsning af de ovennævnte problemer. I forbindelse med kurset forsøgte jeg at aktivere de studerende ved at lægge 13 spørgsmål ud på nettet til hvert forelæsningsemne. De lå der inden forelæsningen og jeg bad dem bruge dem som inspiration til diskussion hjemme og til øvelserne. Jeg lagde med vilje ikke svar ud, men sørgede for gennem mine forelæsninger at henvise til spørgsmålene når jeg kom til svarene og opfordrede i øvrigt de studerende til at spørge enten til undervisningen eller pr. mail, hvilket rigtig mange har benyttet sig af.

Det viste sig at de var overvældende glade for disse spørgsmål, og jeg har derfor fået lyst til at udforme et lidt mere omfattende undervisningsmateriale, som skulle støtte øvelserne og være udgangspunkt for diskussioner i læsegrupperne. Mit mål er at et sådant materiale vil kunne stimulere udviklingen og anvendelsen af det patobiologiske sprog på en mere aktiv måde end en lærebog og stimulere til dybdeindlæring og forståelse af de patobiologiske processer. Oprindelig var det min plan at udarbejde og teste et materiale allerede til det kursus vi var i gang med, men tiden til eksamen nærmede sig og min faglige vejleder advarede mig om ikke at dynge mere på de studerende uden at være meget bevidst om hvorvidt der var et behov og om de studerende også ville have glæde af et sådant supplerende materiale.

Af frygt for at sende uklare signaler til de pressede studerende satte jeg mig derfor for at udarbejde et forslag og i stedet starte med at præsentere en fokusgruppe for det. Det ville samtidig give mig anledning til:

- At få mere at vide om hvordan de studerende læser og arbejder og derfor give mig mulighed for at kende min målgruppe bedre.
- At undersøge om de studerende var enige med mig i at et undervisningsmateriale med fordel kunne anvendes i øvelsesundervisningen og bruges supplerende til eksamenslæsningen.
- At undersøge om de studerende selv er opmærksomme på det uhensigtsmæssige i et “surface approach” og hvordan de forholder sig til det.

Fokusgruppeinterview

Metode

Interviewet fandt sted 30.juli 2009 kl.13-15, altså 3 måneder efter at de studerende havde været til eksamen i Patobiologi. I alt havde 6 kvindelige studerende indvilliget i at deltage. 3 fik forfald, så tre studerende deltog (i interviewet kaldet B., C. og E.). De havde alle netop gennemført 2. år af veterinæruddannelsen.

Spørgsmålene havde jeg forberedt forinden og min plan var at lade dem snakke så meget som muligt og kun få dem på banen igen, hvis de kørte ud ad en tangent. Da det var midt i ferien var det ikke muligt for mig at have en assistent til at tage noter.

Resultat: Opsummering af pointerne fra fokusgruppeinterviewet:

De studerende oplever et alvorligt tidspres. De oplever nærmest "at gå i skole" og synes ikke der er tid til selvstændigt arbejde, hvor de selv skal ud at søge viden. De vil allerhelst have viden "serveret".

De er opmærksomme på at de primært læser med henblik på at bestå eksamen og at det læste ofte er hurtigt glemt.

De oplever forelæsningerne som en god, strukturerende indlæringsform.

De mener, at man bør kunne komme uforberedt til såvel forelæsninger som øvelser og stadig få meget ud af undervisningen. Dvs. der er et ønske om at øvelsesundervisningen ikke forudsætter, at man allerede har arbejdet med stoffet hjemme.

De oplever øvelsesundervisningen som en mulighed for, at få personlig feedback fra underviserne og få gode forklaringer face-to-face. Dette taler imod udelukkende at anvende e-learning.

De siger at de ikke bevidst bruger viden fra andre fag. De oplever fagene adskilt.

Muligvis er det under halvdelen af de studerende der er i en læsegruppe, der mødes ugentligt. Af den grund kan man ikke anvende TLAer, som forudsætter at de studerende er organiseret i læsegrupper. Formentlig vil der være stor modstand mod opgaveløsning, der forudsætter gruppearbejde.

Hvis man vil lave en undervisningsform, hvor opgaver lægges ud på nettet, skal svarene på disse opsummeres i plenum eller på hold, så individualisterne også kan være med.

Undervisningen skal set fra de studerendes vinkel, være dækkende for pensum (det der kan stilles eksamensspørgsmål i).

Der er ingen tvivl om, at de studerende allerede har en studieform, som favoriserer "surface" indlæring. Det oplivende er, at de personligt hver især har fundet strategier, der virker for dem og at de fælles faktisk kan blive enige om at forståelse, der holder på længere sigt bør indeholde en aktiv holdning til indlæring.

De vil godt kunne kapere nogle mere udfordrende øvelser og det vil være relevant at se på om man kan udvikle et undervisningsmateriale, der kan være med til at støtte "deep learning" i øvelsessammenhæng.

Hvordan kan man få histologiske præparater til at fortælle historie?

Løsningsforslag

Ud fra interviewet blev det klart, at såfremt vi havde ønsker om at ændre noget skulle vi være varsomme med ikke at kaste de elementer i undervisningen, der virker, overbord. De studerende var samstemmende enige om, at der ikke måtte "pilles ved" forelæsningerne. Efter at have vist dem mit første udkast til et øvelsesmateriale blev de kendeligt oplivede, men pointerede samtidigt at det ville være forkert at satse på at det kunne afløse øvelsesundervisningen, som en slags e-learning. Der udtryktes et stort behov for at bevare face-to-face kontakten, hvor vi går rundt mellem bordene og hjælper de studerende og hvor der er mulighed for personlig feedback.

For at øge elementet af aktiv indlæring vil det være formålstjenligt at udforme et øvelsesmateriale, som kan bruges som et didaktisk spil baseret på "problem based learning (PBL)". Dette indbefatter følgende faser:

- Devolution, hvor spørgsmålet stilles og rammerne evt. forklares
- Handling, hvor den enkelte student kan sidde med mikroskopet og reflektere over løsningen
- Formulering, hvor løsningen diskuteres med sidemanden
- Validering, hvor de studerendes løsning udsiges i plenum og modtager feedback fra underviseren

- Institutionalisering, hvor læreren samler op på svarene og kommer med den fyldestgørende besvarelse.

I løbet af kursets mikroskopiske øvelsesdel præsenteres de studerende for ca. 25-30 præparater af patologiske manifestationer, som de skal kunne genkende og beskrive ved anvendelse af patologisk fagterminologi. Derudover fordres det at de kan bruge disse manifestationer til at redegøre for de patobiologiske mekanismer der har ledt frem til disse manifestationer.

For at komme dertil skal de være i stand til:

- At erkende at der er tale om en patologisk manifestation. Dvs. de skal være i stand til at koble det de ser i mikroskopet (som de kan beskrive) med deres viden om anatomi (som er det normale) og ekstrahere, hvad af det de ser, som er forandringer.
- At erkende hvilke af disse forandringer der er resultater af en proces, nemlig kroppens forsvar mod et patologisk agens (bakterie, virus, giftstof. . .) eller tilstand (mangel på ilt). Disse typer af respons gennemgås ved forelæsningerne. Andre typer forandringer kan være *arte fact'*er, som opstår ved præperation af vævet.

Disse to typer erkendelse indgår i fig. 12.2 nedenfor, som hhv. 2A og 2C.

For øjeblikket træner vi ikke bevidst de studerende i at opnå denne erkendelse. Mange af dem når der til på trods af denne mangel på træning i aktiv erkendelse, men nogle når aldrig der til. Disse holder sig i stedet til at lære præparaterne udenad, et “surface approach”, man ikke kan fortænke dem i, men det lærte glemmes ofte kort tid efter eksamen.

Det er mit mål gennem øvelsesmaterialet at give begge grupper en håndsrækning i ovennævnte erkendelsesproces.

Derfor har jeg stillet følgende spørgsmål:

1. Hvordan skal et sådant - forbedret - opgavesæt se ud?
2. Kan man opstille nogle generelle principper for, hvordan den enkelte opgave skal opbygges?
3. Hvordan vil jeg anvende opgavesættet i øvelsesundervisningen, så det bedst muligt tilgodeser ønskerne fra de studerende og så vi beholder de gode elementer fra vores tidligere undervisning?
4. Ud fra en pædagogisk vinkel er det interessant at finde ud af, hvorfor den beskrevne type opgave formentlig vil fungere.
5. Ændres udbyttet af undervisningen i forhold til den nuværende undervisning?

I det følgende vil jeg prøve at besvare spørgsmålene.

Hvordan skal et sådant - forbedret - opgavesæt se ud?

Et eksempel er vedlagt som appendix A.

1. De studerende skal præsenteres for et billede svarende til det patologiske præparat (et sygt væv med forandringer). Ved siden af skal der være et billede af normalt væv fra samme organ.
2. Med spørgsmål skal de opfordres til at beskrive forskellen i egne ord. Evt. kan man bede dem sætte pile på forandringerne. Hvad er "unormalt".

Med spørgsmål 1 og 2 (Appendix A) bibringes de studerende den første type erkendelse som jeg beskrev ovenfor, se også figur 12.2, 2A.

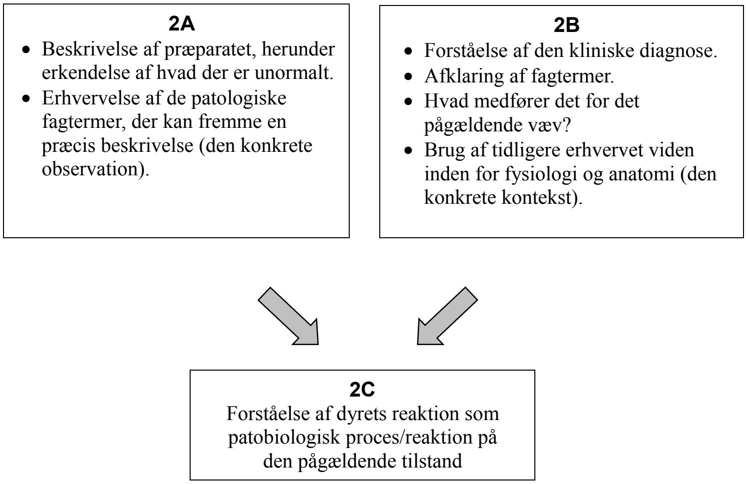
- Med et patologisk præparat følger altid en klinisk diagnose eller beskrivelse. (Dyret er, når patologen ser det dødt og de behandlende dyrlægerne har sendt det over til patologerne for at få den endelige diagnose. Inden da, har de behandlende dyrlæger gjort deres observationer om dyret og sammenfattet disse i en klinisk diagnose. Det er denne diagnose, dyret blev behandlet ud fra. Når dyret er dødt er det patologens opgave at finde ud af, hvorvidt de behandlende dyrlæger havde ret eller tog fejl i deres kliniske diagnose). Fra denne diagnose ved vi altså en hel del om hvordan dyret har haft det inden det døde, men det forudsætter at de studerende kan forstå de ord som klinikerne bruger og dem har de studerende på 2. år endnu ikke tilegnet sig. Det er derfor er nødvendigt med ordforklaringer, hvis de studerende skal bruge den kliniske diagnose til at forstå forløbet mens dyret levede og dermed den patobiologiske proces der medførte døden.
  - I opgaven kan ordene forklares (jvf. spørgsmål 3 og 4 i Appendix A): hæmolytisk betyder at dets blodlegemer er gået i stykker, anæmi at det har for få røde blodlegemer).
  - Derudfra kan man spørge de studerende om de med egne ord kan beskrive den tilstand som dyret har været i. (De vil formentlig ud fra deres anatomiske og fysiologiske viden kunne slutte sig til at der må have været iltmangel i vævet og at der må være et overskud af hæmoglobin i vævet (fra de ødelagte blodlegemer, som dyret på en eller anden måde må reagere på). Hermed får vi inddraget den kliniske viden (Se fig. 12.2, 2B) og får ansporet de studerende til at

tænke det patologiske præparat som resultatet af en proces (Se fig. 12.2, 2C).

– Man vil kunne spørge dem (jvf. spørsmål 6 i Appendix A), hvilke fagtermer de mangler i, at kunne beskrive dyrets tilstand i patobiologiske termer (De vil måske svare “iltmangel” og man vil kunne fortælle dem at det hedder hypoxi, hvortil nogle vil sige: “aha”, for det burde de faktisk vide fra fysiologiundervisningen).
– Derefter kunne man bede dem om at redegøre for en af de patobiologiske processer som er foregået i præparatet i timerne op til at dyret døde. Svarende til spørgsmål 7 i Appendix A: Hvad sker der med celler i et område der lider af denne tilstand? - og gennem de efter følgende spørgsmål 7-15, sker der en pædagogisk kobling mellem de observerede forandringer (2A) og viden om den relevante patobiologiske proces (2B). Denne medfører en øget forståelse af den patoblogiske proces (2C). Se fig. 12.2.
– Endelig kunne man bede dem beskrive præparatet, som de ville gøre det for en kollega hvor de anvender de rigtige patologiske fagtermer, som er et af de ILO vi har opstillet for kurset.

Kan man opstille nogle generelle principper for hvordan den enkelte opgave skal opbygges?

Den patobiologiske skabelon for hvordan aktiverende opgaver kan se ud, rummer en generel opskrift på hvordan man kan lave opgaver, der guider den studerende hen imod for en kontekstuel forståelse af sit fag. Det er min overbevisning, at det er muligt billedligt talt at “tage de studerende ved hånden” og lade dem gå vejen igennem præparatet, afdække de aktuelle celleforandringer og dets kliniske kontekst og dermed facilitere en erkendelsesproces, der rummer processuel forståelse. Ved igen og igen at gentage denne proces med forskellige præparater, hvoraf nogle ligner hinanden, opbygges af et “vidensnetværk”, som kan blive basis for senere indlæring af speciel patologi og klinisk viden. Jeg har forsøgt at se om man kan beskrive denne guidning i mere generelle termer, da jeg tror at det er et generelt menneskeligt træk at vi opnår erkendelse ad denne vej. Hvis det er rigtigt vil skabelonen også kunne omsættes til andre fagområder. En undersøgelse om hvorvidt det er tilfældet ligger dog udenfor denne opgaves rammer. Resultatet ses i figur 12.3 hvor den generelle proces er placeret til venstre i skemaet og det brugte eksempel til højre.



Figur 12.2. Beskrivelse af opgavens elementer (2A og 2B), som skelet for indlæringen, og forudsætning for erkendelse af den patobiologiske proces (2C).

Hvordan vil jeg anvende opgavesættet i øvelsesundervisningen, så det bedst muligt tilgodeser ønskerne fra de studerende og så vi beholder de gode elementer fra vores tidligere undervisning?

Ud fra mit interview af fokusgruppen stod det klart, at man skal passe på ikke at ødelægge nærheden med de studerende og muligheden for direkte at give feedback i øvelsesundervisningen. Med et udvidet opgavetilbud vil der formentlig være endnu mere brug for feedback, sammenlignet med nu, hvor de blot sidder og kigger og genfinder strukturer i deres præparater.

En egentlig gennemgang af præparaterne kunne derfor med fordel indlægges i forelæsningerne, som eksempler i forbindelse med den teoretiske gennemgang af kroppens respons på sygdom.

Øvelserne kunne derfor begynde med devolutionsfasen, hvor de studerende tager præparatkasserne frem og løser den pågældende opgave i hæftet (handlingsfasen) samtidig med at de ser på præparatet fra kassen. Det, præparatet giver dem ekstra i forhold til billedet er, at de vil kunne gå op og ned i forstørrelse og få en mere "patologisk" oplevelse ved selv at bruge mikroskopet.

Generaliseret beskrivelse	Skabelon til patobiologiske opgaver	Eksempel (se Appendix A)
1. Objektiv beskrivelse af objektet/situationen i egne ord	1. Objektiv beskrivelse af præparatet i egne ord	Beskriv det du ser?
2. Tilegnelse af fagtermer til præcisering af beskrivelsen	2. Kan tilstanden beskrives ved en faglig term?	Hvad betyder cellelysis? Hvad betyder hydropisk degeneration?
3. Beskrivelsen af konteksten	3. Hvad er den kliniske diagnose? Forklar hvad ordene betyder	Dyret har hæmolytisk anæmi, dvs. dens røde blodlegemer går i stykker, hvilket medfører frit tilgængelige hæmgrupper og iltmangel
4. Anvendelse af tidligere erhvervet viden til forståelse af konteksten	4. Hvilken tilstand har dyret og det specifikke væv været i? Hvad karakteriserer denne tilstand?	Vævet har manglet ilt (hypoxi) og hæm grupper opsamles af specielle makrofager, hvilet kaldes hæmosiderose
5. Integrering af det observerede i konteksten	Beskriv denne cellulære proces og de mekanismer vævet reagerer med	Derfor har der været mangel på ATP, de cellulære ATP krævende pumper holder op med at fungere, iongradienter udviskes… Alt sammen leder det hen mod hydropisk degeneration og cellelysis
6. Hvilken betydning har den kontekstuelle viden for den aktuelle observation	Beskriv det pågældende præparat i patobiologiske fagtermer og angiv vigtige informationer	I præp. ses celler der undergår hydropisk degeneration. Bemærk tilstedeværelsen af cellekerner i nogle celler, hvoraf det kan udledes at processen på dette stadie stadig er reversibel i andre områder…
7. Udledning af generelle principper (vidensnetværk)	Kender du andre tilstande, der har samme cellulære manifestation?	Celler ser sådan ud når de er på vej til at dø ved koagulationsnekrose
7. Mulighed for at opstille hypoteser og teste andre observationer og lave følgeslutninger	Hvordan ville forløbet have været hvis dyret havde overlevet? Hvilke reparationsprocesser kunne være aktuelle her (det omkringliggende vævs reaktion)	Hvis der tilføres ilt, hvad vil der så ske og hvordan mon det vil se ud?

Figur 12.3. Skabelon for opbygning af opgaver der faciliterer opbygning af et vidensnetværk

Derefter vil de skulle diskutere med naboen eller resten af bordet (formuleringsfasen). Det gør de allerede nu i et vist omfang og det er de glade for. I valideringsfasen vil man bede de studerende svare i plenum og give feedback i plenum. Endelig vil institutionaliseringsfasen svare til en hurtig gennemgang af en korrekt præcis beskrivelse af præparatet, sådan som de studerende selv også skulle have gjort det i spørgsmål 16 i mit eksempel (Appendix A).

Ud fra en pædagogisk vinkel er det interessant at finde ud af, hvorfor den beskrevne type opgave formentlig vil fungere.

Det er min overbevisning at denne tilgang til undervisningen vil imødekomme de studerendes "krav" om at blive guidet igennem præparaterne og gøre det muligt for dem at få noget ud af undervisningen også selvom de ikke er velforberedte. Spørgsmålene hjælper dem til at fokusere på tilegnelsen af de termer der er væsentlige for netop den pågældende proces. De tvinges til at "se" på præparatet og lave en objektiv beskrivelse (hvilket de gerne skulle kunne til eksamen) og selvom de fornægter at have en viden fra anatomi og fysiologi, så tvinger spørgsmålene dem til at erkende at det nok ikke er korrekt og får dem til at indse at de allerede bruger deres viden fra disse fag og at de ligeså godt bevidst kan bygge ovenpå den i stedet for at fornægte den.

Spørgsmålene skulle således være med til at bevidstgøre for dem, at deres viden indgår som et netværk af informationer og stimulere deres associationsevne. Der er ingen tvivl om at de derigennem kommer til at træne deres evne til at associere og genkendelse af mønstre. Dette vil uden tvivl styrke deres indlæringsevne i de kliniske fag, da det netop er denne evne til mønstergenkendelse hele det kliniske virke baseres på.

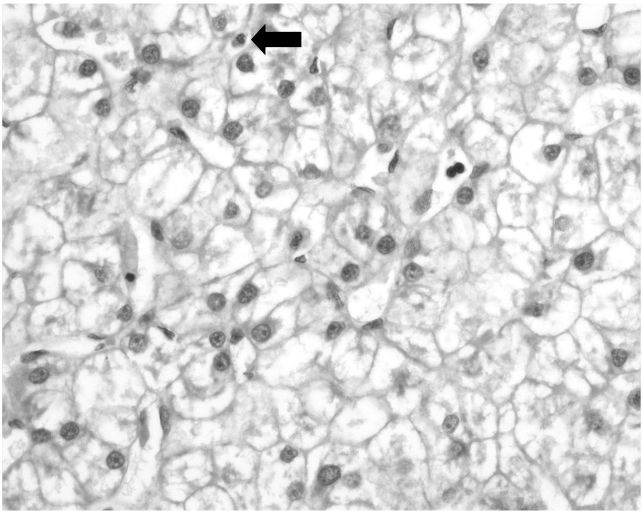
Ved allerede på 2. år at bibringe dem en opskrift på hvordan man kan danne et vidensnetværk - et stillads, som en af de studerende formulerede det i interviewet - skaber man præmisserne for at man kan lave logiske følgeslutninger inden for sit fag. De studerende skulle, hvis man praktiserede opgaveløsning af denne type i flere fag, gerne opleve en sammenhængskraft mellem fagene, der ikke i så høj grad bygger på om hvorvidt lærerne rent faktisk taler sammen (som de nævnte i interviewet), men som skyldes at fagene rent faktisk hænger sammen.

Ændres udbyttet af undervisningen i forhold til den nuværende undervisning?

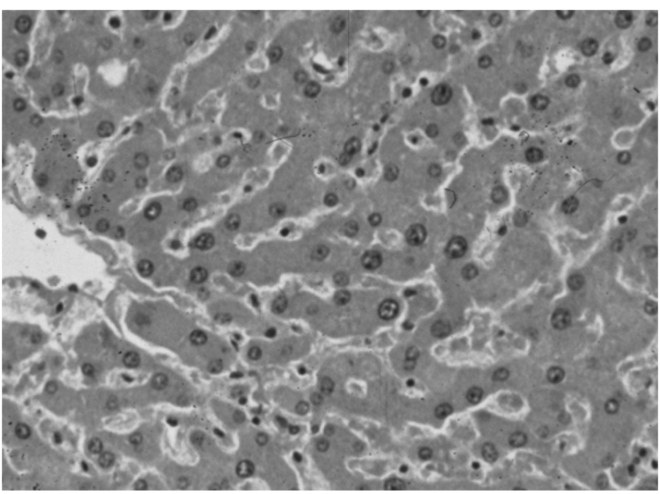
Det er mit håb, at man ved at træne de studerende i opgaveløsning og diskussion vil kunne opnå en dybere forståelse af det patobiologiske pensum. Træning i at arbejde med de patobiologiske fagtermer og derigennem forbedre deres evne til at observere og beskrive de patologiske manifestationer (øjebliksbillederne som de fremstår på histologiske slides) giver en basis for forståelse af de patobiologiske mekanismer og processer, som væv reagerer på sygdom med.

At opbygge et vidensnetværk og kende mekanismerne er første trin på vejen til at forstå et sygdomsforløb og tilmed den væsentligste forudsætning for at kunne forudsige og gribe ind i selv samme forløb. Netop det en dyrlæge forventes at kunne.

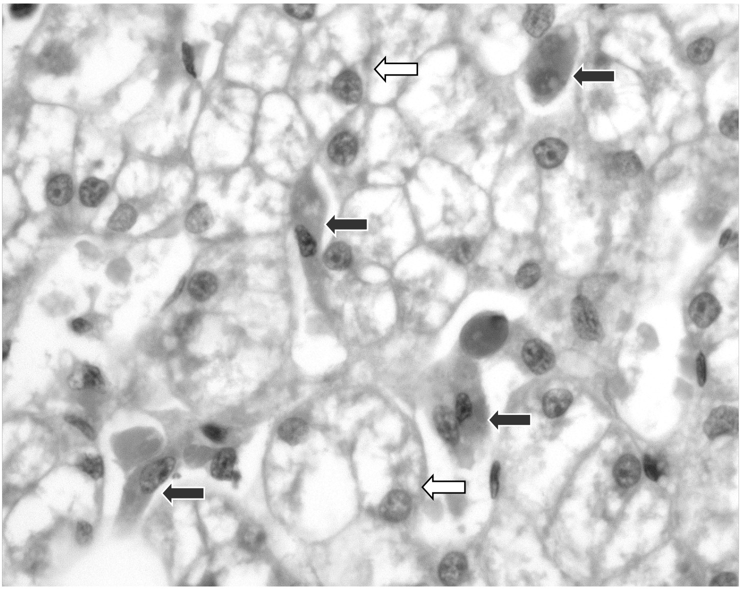
A Appendix: Eksempel på opgavesæt udformet efter den omtalte skabelon



Figur A. Patologisk lever fra hund.



Figur B. Udsnit af normal lever.



Figur C. Større forstørrelse (60x) af område fra patologisk lever fra hund .

Spørgsmål til diskussion:

1. Se godt på den normale og den syge lever. Beskriv forskellen i egne ord. Prøv at se hvilke celletyper der er og hvordan de ser ud.
2. Den kliniske diagnose er: en hund med hæmolytisk anæmi
3. Forklar med dine egne ord hvad hæmolytisk betyder
4. Forklar med dine egne ord hvad anæmi betyder
5. Beskriv med egne ord, hvilken tilstand dyret har været i og hvad hvad det betyder for cellerne i leveren.
6. Hvad er forskellen på hypoxæmi og hypoxi og hvilken tilstand er der tale om her?
7. Hvad sker der med celler i et område der lider af denne tilstand?
8. Oven for ses to billeder af et snit (20x og 60x forstørrelse) af en lever hos en hund, der har haft denne tilstand, hvordan har cellerne, som de hvide pile i Figur C peger på, reageret?
9. Hvad kaldes denne tilstand?
10. Havde den været den reversibel, hvis dyret havde overlevet. Hvorfor/hvorfor ikke?
11. Den sorte pil på Figur A peger på en celletype. Hvilken er det? – og hvorfor er den tilstede i dette præparat?
12. De sorte pile på Figur C peger på nogle specialiserede celler i leveren. Hvilke?
13. Hvad indeholder de?
14. Hvorfor? Og hvad kaldes denne tilstand?
15. Hvorfor er det smart at leveren har oprydningsceller, så det som pilen peger på ikke ligger frit?
16. Tag nu præparatet igen og beskriv det i patologiske termer så nøjagtigt at din sidemand ikke er i tvivl om hvad det er.
17. Skriv denne beskrivelse ned herunder, så har du den til når I repeterer og I kan øve jer i at genkende præparatet ud fra den andens beskrivelse.

Part III

Planning courses with many involved teachers

13

Undervisning i dele af fagene “Genetik”og “Molekylærgenetik” ved LIFE

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Introduktion

Denne rapport er udført i relation til den teoretiske del af adjunktpædagogikum. Projektet omhandler del-elementer af undervisningen i de to fag “Genetik” (GE) (kursus nr. 240066 – 7,5 ECTS) og “Molekylærgenetik” (MGE) (kursus nr. 240066 – 15 ECTS). Kurserne er opbygget således at de har fælles forelæsninger og teoretiske øvelser (mandag og torsdag), mens der tirsdag og onsdag er laboratorieøvelser kun for MGE. De sidstnævnte laboratorieøvelser indeholder også klasseundervisning. Derudover er der lagt én enkelt hel dag med laboratorieøvelse (molekylærgenetisk lab) for det lille kursus (GE). Endelig skal de studerende på begge kurser arbejde med en teoretisk case i grupper – en case som de har mulighed for at få vejledning til og som de samtidig eksamineres i ved en mundtlig eksamen. De studerende går derfor til mundtlig eksamen hos deres case-vejleder. Udover mundtlig eksamen er der skriftlig eksamen som er ens for begge kurser.

På kurserne var jeg ansvarlig for følgende elementer:

1. Forelæsning over emnet “Population genetics” (torsdag 7/5 13-14.30) – begge kurser.
2. Forelæsning over emnet “Complex inheritance” (mandag 11/5 13-14.30) – begge kurser
3. Teoretiske øvelser i “Complex inheritance” (mandag 11/5 15-17) – begge kurser.

4. Laboratorieøvelse for halvdelen af GE-kurset (20 studerende) (torsdag 14/5 9-17)

Kombinerede forelæsninger og klasseøvelser over emnerne:

5. Genetic barcoding of biological diversity, Molecular evolution and biological clocks (tirsdag 19/5 9-12 og 13-15) – kun MGE.
6. Construction of phylogenies based on genetic data (onsdag 20/5 9-12) – kun MGE.
7. Derudover havde jeg udarbejdet 4 forskellige cases – 2 beregnet på studerende fra GE-kurset og 2 beregnet på studerende fra MGE-kurset. I alt vejledte jeg 5 case-grupper og havde derved 16 studerende til mundtlig eksamen.

Således var jeg underviser i de fleste kendte undervisningssituationer – men ikke så meget af hver.

Denne opgave vil især forholde sig til 3 af de ovenstående 7 punkter, nemlig 1 og 2 (forelæsninger for begge kurser) samt 4 – en-dags-laboratorieøvelsen for Genetik-kurset.
I forbindelse med tema 3: "Learning objectives and constructive alignment" på Kursus i Naturfaglig Universitetspædagogik og Didaktik (KNUD) lavede jeg en analyse af GE-kurset. Analysen fandt at faget var skruet fornuftigt sammen (constructively aligned), og at der derfor var en forholdsvis god overensstemmelse mellem aktiviteterne og det som de studerende forventes at skulle kunne efter at have taget kurset (Intended Learning outcomes – ILOs). I lyset af at jeg allerede har gennemgået det ene af kurserne, og fordi det kun er en mindre del af kurserne jeg er ansvarlig for, har jeg valgt at fokusere på hvad jeg gerne ville have de studerende til at 'få med hjem' fra de specifikke del-elementer.

Udfordringerne

Som beskrevet ovenfor har jeg bl.a. fokuseret på emnet forelæsning, og i de to kurser bliver dette til forelæsninger i store klasser, da der gerne er 40-50 studerende til disse. Emnet er spændende og yderst relevant, omend ret traditionelt – hvordan får man 'fanget', involveret og aktiveret de studerende? Specielt var jeg blevet inspireret af en film af John Biggs som vi så på kurset "Introduktion til Universitetspædagogik", hvor forskellige metoder til at aktivere de studerende under forelæsninger for store klasser blev præsenteret. Det andet emne jeg har valgt at koncentrere mig om er laboratorie-øvelsen som skulle afholdes for de studerende på det lille kursus (GE-kurset). Den øvelse var jeg, som det eneste, også ansvarlig for i det foregående års kursus, og jeg havde nogle klare intentioner om at forbedre den, selv om den forløb udmærket året før.

Forelæsningerne

Udfordringen for mig var egentlig til at føle på. Kapitlerne der omhandler de to emner jeg skulle holde forelæsning over, henholdsvis molekylær evolution og populationsgenetik (kapitel 14) og kvantitativ genetik (kapitel 15), er placeret som de to sidste kapitler i lærebogen. Begge områder virker lidt som ’isolerede øer’ i forhold til resten af kursets pensum, der meget går på molekylære/fysiske aspekter ved genetik, mens populationsgenetik og kvantitativ genetik ofte bruger matematiske eller statistiske metoder. Dette er specielt problematisk, da kursisterne typisk ikke har haft statistik på det tidspunkt hvor de følger genetik-kurserne. Det øvrige pensum består af 10 andre kapitler i lærebogen – og der afholdes forelæsninger over disse af samme forelæser. Jeg ville derfor lidt komme som en fremmed fugl, og begge gange med et nyt emne som ved første øjekast kan synes at ligge i udkanten af deres pensum. Ved min første forelæsning om populationsgenetik havde en undervisningskollega (statistiker) fra et andet institut dog startet op på emnet om formiddagen, hvor han gennemgik ud fra bogen de formler mv. som bruges i den mest grundlæggende populationsgenetik. Ideen var så, at jeg skulle komme med den mere anvendelsesorienterede vinkel og prøve at forklare hvilken betydning de populationsgenetiske begreber havde i faktuelle problemstillinger.

En enkelt dags laboratorie-øvelse

Den didaktiske udfordring er måske her især, at de studerende kun får den ene gang i laboratoriet. Så hvordan skaber man en meningsfuld øvelsesgang, hvor de studerende føler at de får noget med hjem? Øvelsen blev indført fordi de studerende på GE-kurset følte at de manglede noget i forhold til dem på MGE-kurset, og ved sidste års evaluering efterspurgte de flere øvelsesgange. Undervisergruppen for kurset har svaret at hvis man ønsker mere laboratoriearbejde må man tage det store MGE-kursus.

Planlægning af forelæsninger

Min grundlæggende ide med forelæsningerne var især at præsentere de to områder og specielt at give inspiration, ved at vise hvordan genetikken blev brugt i anvendt forskning til at løse nogle konkrete problemer. Dette ligger helt i tråd med min egen tilgang til videnskab, og er også det som generelt kendetegner uddannelserne på LIFE.

Populationsgenetik

Jeg havde nok erkendt at det var urealistisk at de studerende skulle tilegne sig mange handlingskompetencer inden for et område som populationsgenetik med blot to gange 2x40 minutters forelæsning (min egen og statistikerens) og 2 timers efterfølgende opgaveregning. Mit mål var derfor, som også udtrykt på første slide til de studerende, at "vise hvordan populationsgenetik er relevant i mange biologiske problemstillinger" samt at "få dem til at tænke i populationsgenetiske baner". Dette ville jeg illustrere ved brug af min egen forskning, som er i nåletræer/juletræer. Jeg ville derudover prøve at understrege de 4 grundlæggende processer der er altafgørende i populationsgenetik. Som beskrevet ovenfor ville jeg gerne indføre nogle af ideerne fra eks. Biggs (1993), hvor man tilfører dynamik og dialog til forelæsninger for store hold. Jeg ville gøre det ved at indlægge en summeopgave allerførst i forelæsningen hvor de skulle tale med sidemanden om et problem i 2 minutter, hvorefter vi skulle samle op i fællesskab. Tanken var at 'kickstarte' seancen, og få dem aktiveret. Dette blev så gentaget med yderligere en opgave relativt kort tid efter, denne gang fik de 5 minutter til at diskutere med sidemændene.

Kvantitativ genetik (Complex inheritance)

Her var opgaven lidt anderledes, idet jeg ikke fandt det hensigtsmæssigt at frigøre mig ret meget fra lærebogen, idet der ikke som ved populationsgenetik var en forudgående forelæsning. På den måde var jeg nok underlagt det som Gibbs (1981) kalder "cover the ground" – dvs. jeg ville være sikker på at de studerende kommer igennem pensum. Derfor brugte jeg mange figurer fra lærebogen for at give dem lejlighed til at spørge vedrørende disse. Samtidig var der en del om statistiske begreber som de studerende ikke kendte, men som er svære at komme udenom. Denne gang lagde jeg en gruppeopgave til sidst i forelæsningen, hvor de skulle lave en praktisk opgave med at udlægge et feltforsøg til at undersøge kvantitative genetiske egenskaber. Dette for at give dem et indtryk af metoder og samtidig understrege vigtigheden af både genetik og miljø, plus samspillet mellem disse.

Gennemførelse og evaluering af forelæsninger

Populationsgenetik

Min egen oplevelse var at forelæsningen forløb nogenlunde. Den første opgave syntes at virke efter hensigten – de studerende virkede aktiverede – men det var alligevel svært at få dem til at komme med løsningsforslag på problemet. Det lykkedes dog at få lidt snak i gang om det. Anderledes trægt gik det med at komme i gang med den anden opgave. Hvor Biggs (1993) meget pointerer at summe-møder med opgaver skal skabe et afbræk, så var den tidsmæssige afstand mellem mine to summemøder nok for lille. Ligeså kneb det med at opnå det didaktiske miljø (Winsløw; 2007) som gør at de studerende accepterer det didaktiske spil, men dette tror jeg er nødt til at komme gennem øvelse fra min side. Visse af mine slides var nok for indviklede/informationsmættede, og kunne med fordel være brudt op i flere. Dette skyldes nok at de mestendels viste min egen forskning, hvor man jo ofte i foredrag og artikler til kollegaer tilskyndes til at gøre tingene så kompakt som muligt. Jeg havde med vilje undladt at oploade mine slides før forelæsningen, for at man ikke skulle kunne gætte svaret på opgaverne. Dette var en klar fejl – en anden gang vil jeg lave separate slides til opgaverne, og så oploade resten før. Det undgås derved at de studerende anvender unødige ressourcer på at skrive noter, men i stedet bruger energien på at forstå hvad der foregår – jvf. Gibbs (1981) punkt 1.6.

Kvantitativ genetik (Complex inheritance)

Denne forelæsning forekom mig mere problematisk end den første. Det virkede som om de studerende ikke havde så meget interesse i emnet, eller måske havde de slet ikke forstået noget af det de havde læst. Opgaven til sidst fungerede sådan set udmærket, men den kom for sent - skulle have været puttet ind i midten. Der var flere spørgsmål til figurerne fra bogen, som jeg syntes det var svært at besvare fyldestgørende, bl.a. pga. af de studerendes manglende forudsætninger i statistik.

De studerendes evaluering af underviseren

De studerende har efter kurset kunnet udfylde en kursusevaluering elektronisk, herunder en vurdering af de enkelte undervisere. Jeg har ikke haft indflydelse på udformningen af skemaet, som er ret standardiseret. Evalueringen kan ses i appendix A. Mest slående er nok at der er meget stor forskel på de studerendes tilfredshed, afhængig af om de har fulgt GE eller MGE kurset. For eksempel var ca. 87 % af respondenterne fra GE neutrale eller enige i at "det af underviseren anvendte materiale passer til kursets faglige indhold" – det tilsvarende tal for MGE var kun 56 %. Alle (100 %) af respondenterne fra GE var neutrale eller enige i at "underviseren stimulerede mig til at reflektere over faglige emner". For MGE-respondenterne var dette tal kun 56 %. Denne forskel er slående, og giver anledning til overvejelse. Der var i begge evalueringer kommentarer om at der var for meget om træer/skov, hvilket i hvert fald peger på at der nok skal findes flere alternativer eksempler. Tallene fra de to kurser er dog ikke helt sammenlignelige, idet halvdelen af GE kurset havde haft en lab-øvelse som jeg stod for, mens MGE havde haft halvanden dags undervisning som GE kurset ikke havde deltaget i.

Fremtidige forbedringer af forelæsningerne

Et grundlæggende spørgsmål er jo om der i det hele taget skal være to tilsvarende forelæsninger næste år, eller om man skal organisere noget andet undervisning – jf. eksempelvis Gibbs (1981): "Twenty terrible reasons for lecturing". Jeg tror det vil blive svært at få brudt isolationen i forhold til resten af kurset, dvs. integrere populationsgenetik og kvantitativ genetik mere med den øvrige undervisning på kurserne. Derfor vil der sikkert også være to forelæsninger med de to emner næste år.
Nedenstående punkter vil jeg prøve at implementere i kommende forelæsninger:

- Fortsætte med at finde relevante eksempler fra virkeligheden for de studerende. Det tyder på at der især skal gøres en indsats for at få fanget de studerende fra MGE.
- Forberede flere og endnu bedre opgaver til brug for summemøder, og sørge for bedre spredning af disse. Især skal jeg tænke på at lave meget åbne spørgsmål til summeopgaverne, for derved at forbedre chancen for

svar fra de studerende. Måske opstille mulige svar til opgaverne som der kan vælges/stemmes om.

- Forbedre min evne til at ’iscenesætte’ summemøder og andre mellem-aktiviteter i forelæsningen.
- Ved den mundtlige eksamen skal de studerende på MGE trække en figur som de skal forklare (gælder ej for GE). Disse figurer tages fra bogen. En potentiel mellem-aktivitet i forelæsningen er derfor at bede de studerende om at forklare figurer fra lærebogen for hinanden. De kunne starte parvis. Disse to kunne så bagefter forklare et andet par hvad figuren viser, og derved afsløre om alle har forstået figurerne rigtigt. Til sidst kunne der samles op i plenum. Denne øvelse har den oplagte fordel, at den er fuldstændigt allignet med ILOs for kurset.
- Finde grafiske animationer på nettet der forklarer eks. populationsgenetiske begreber, og bruge disse som afbræk i forelæsningen, og som udgangspunkt for diskussion.
- Sørge for at oploade slides på nettet inden forelæsningen, og derfor lave separate slides for opgaver, der så ikke oploades inden.

Planlægning af enkelt dags laboratorie-øvelse

Modsat forelæsningerne havde jeg stået for denne øvelse på sidste års GE-kursus (2008). Da de studerende kun har denne ene øvelsesgang i laboratoriet, stiller det naturligvis sine begrænsninger. Der kan ikke forventes at opnå egentlige handlingskompetencer, og det er svært at undgå at øvelsen får et “kogebogs-præg”, eller bliver “aktivitet for aktivitetens skyld” (Weiss et al.; 2003). Målet for øvelsen i 2008 var at give de studerende en fornemmelse af hvad der foregår i et molekylærgenetisk laboratorium, og at de fik prøvet flere forskellige teknikker og derved også fik mulighed for at få noget teori om disse. Øvelsen fik god evaluering. I 2009 havde vi samme målsætning, dog valgte vi at ændre lab-øvelsens del 2 ganske radikalt, for at gøre øvelsen endnu mere problemorienteret. Sidste år havde de studerende arbejdet med mikrosatellitter på nogle DNA prøver vi havde i fryseren. Øvelsen var umiddelbart vellykket og efterligner det man ville lave i et rigtigt videnskabeligt studie, men genotypningen (sidste step) kræver specialudstyr og kan ikke foretages af de studerende selv, da det kræver særlig træning mv. De skulle derfor aflevere deres reaktioner og få de resulterende data tilbage en anden dag. Ydermere arbejdede de alle på at løse det samme fælles problem, hvorved man ved databehandlingen var afhængig af at alle

grupper leverede brugbare resultater, ligesom der kun var ét samlet resultat. En enkelt gruppes manglende resultater kunne således erstattes med eksisterende data fra det af os tidligere udførte forsøg, og dette virkede måske ikke specielt motiverende.
I øvelsen for 2009 bestemte vi at hver enkelt gruppe skulle løse hver deres problem/opgave, og samtidig selv skulle kunne lave alle steps og analysere data selv. Dette krævede simple opgaver. Vi valgte at bruge såkaldte CAPS-markører som indebar at de studerende ville prøve yderligere et molekylærgenetisk redskab i forhold til året før, nemlig restriktionsenzymer. Genotypningen af disse markører kan foretages på en simpel agarose-gel, som de studerende samtidig skulle bruges til at teste noget oprenset DNA fra byg-planter.
CAPS-markørerne skulle bruges til at identificere hvilke nåletræsarter der var i 4 DNA-prøver som hver af 2-mandsgrupperne fik udleveret. Dette betød at vi kunne bytte om på rækkefølgen af de fire træarter i prøverne til hver gruppe, og at grupperne derfor hver især havde unikke løsninger til deres identifikationsopgave. Man kunne altså kun løse opgaven og skrive en rigtig rapport hvis man udførte sit laboratorie-arbejde, og løste sit problem.

Gennemførelse og evaluering af laboratorie-øvelse

Øvelsen indledte jeg med en ca. 10 minutters gennemgang af hvad der skulle foregå, og specielt var der en kort gennemgang af de generelle principper vedrørende de forskellige teknikker der skulle anvendes (eks. ekstraktion af DNA, PCR, etc.). Forinden havde jeg oploadet øvelsesvejledningen (8 sider) og bedt dem studere den nøje, og det var mit klare indtryk at de fleste havde læst den. I øvelsesvejledningen var der anbefalet nogle sider i lærebogen som selvstudium op til øvelsen. Øvelsen var bygget op så flere teknikker kørte sideløbende for at nå så meget som muligt på én dag. Når der eksempelvis var et trin med lang ventetid i protokollen for DNA-ekstraktion fra byg, så skulle de starte med PCR i deres udleverede DNA-prøver med nåletræsarter. I øvelsesvejledningen var der spørgsmål beregnet på evt. ventetid – spørgsmål som relaterede sig til teorien bag teknikkerne – fx “hvordan bevæger DNA sig i en gel”, eller “hvordan virker en CAPS-markør?”
Udover undertegnede var der yderligere to VIP og to laboranter til stede. Dels for at hjælpe med at instruere og tage billeder af geler, dels til at svare på spørgsmål og diskutere diverse emner med de studerende. Der skulle udfærdiges en rapport over øvelsen, hvilket var en forudsætning for at gå til

eksamen. Den skulle indeholde svarene på deres identifikation af træarter i de udleverede DNA-prøver, samt spørgsmålene beregnet til ventetiden. Alle grupper på nær én fik succesrigt identificeret deres træarter, og alle så ud til at arbejdede motiveret med deres opgaver. Det var mit og resten af undervisernes indtryk, at der var generel tilfredshed med dagen blandt de studerende.

Fremtidige forbedringer af laboratorieøvelsen for GE-kurset

Umiddelbart synes jeg at vi har fundet et godt miks af teknikker og opgaver, og har derfor ikke planer om at lave de store ændringer inden næste år. At ændre på øvelsens del 2 fra én type markør til en anden krævede noget forberedelse i DNA-laboratoriet i form af afprøvning og DNA-ekstraktion af nyindsamlede nåletræsprøver, men jeg synes at indsatsen bar frugt i form af en bedre øvelse end året forinden. Den forholdsvis overskuelige opgave og det at de fik resultatet på øvelsesdagen gjorde dem mere engagerede end året før. Den fælles intro er nødvendig og vil blive bibeholdt, men den praktiske gennemførelse af denne kan/skal der nok arbejdes med:

- Eksempelvis ved at stille spørgsmål og derved få de studerende til selv at sige/forklare hvad der skal ske – hvilket skulle være muligt for dem som har læst øvelsesvejledningen forinden.
- Midtvejs og/eller sidst på dagen kunne der også tages en fælles opsamling eller et summemøde, hvor den oversigtslide der blev brugt i introen igen tages frem, og under denne seance få de studerende til selv at forklare hvad de har lavet.

Afrunding

Det har været interessant at blive mere bevidst om de didaktiske processer der gør sig gældende i forskellige undervisningsforløb, og ikke mindst at afprøve de teoretiske metoder introduceret i den teoretiske del af adjunktpædagogikum. De personlige udviklingsformål for min fremtidige undervisning er dels de konkrete forslag til forbedringer af de to typer af undervisning som er behandlet i nærværende rapport, men også fortsat at eksperimentere med nye aspekter af undervisning. Skal man lære at blive god

til at undervise, ja så er det bedste man kan gøre nok at undervise meget - samtidig med at man er bevidst om hvad man laver. Afslutningsvis vil jeg gerne rette en tak til min to vejledere under den praktiske del af adjunktpædagogikum. Faglig vejleder var lektor Claus Ekstrøm, Institut for Grundvidenskab og Miljø, som overværede forelæsningen i populationsgenetik og laboratorieøvelsen. Pædagogisk vejleder var adjunkt Jan Sølberg, Danmarks Pædagogiske Universitetsskole, som også overværede forelæsningen i populationsgenetik. Begge har kommet med værdifulde input i processen som er beskrevet her. Begge har desuden givet sparring vedrørende den vejledning som jeg gav case-grupperne i forbindelse med de to kurser.

A Appendix: De studerendes evaluering af Ole K. Hansen som underviser afgivet på CAMPUS-net

Resultater: 240066 Genetik F09-4, Skema B: Ole Kim Hansen

Statistik	
39	kunne besvare dette evalueringsskema
15	har besvaret dette evalueringsskema
2	har tilkendegivet ikke at have haft denne underviser
2	har tilkendegivet ikke at have fulgt kurset
42.86 %	svarprocent: 15 / (39 - 2 - 2)

1	**Skema B: Evaluering af underviser**		
1.1	**Jeg mener, at det af underviseren anvendte materiale passer til kursets faglige indhold (15 besvarelser)**		
	Helt uenig	1	6.67 %
		1	6.67 %
	Neutral	4	26.67 %
		6	40.00 %
	Helt enig	3	20.00 %
1.2	**Jeg synes, at underviseren var god til at formidle faget klart og præcist (15 besvarelser)**		
	Helt uenig	1	6.67 %
		2	13.33 %
	Neutral	5	33.33 %
		6	40.00 %
	Helt enig	1	6.67 %
1.3	**Jeg mener, at underviseren stimulerede mig til at reflektere over faglige emner (15 besvarelser)**		
	Helt uenig	0	0.00 %
		0	0.00 %
	Neutral	5	33.33 %
		8	53.33 %
	Helt enig	2	13.33 %
1.4	**Eventuelle uddybende kommentarer (15 besvarelser)**		

- For meget skov!
- Lidt for meget snak om juletræer, hvilket tog fokus væk fra forståelsen af det kapitel man havde læst inden forelæsningen.
- Fint

Resultater: 240067 Molekylær genetik F09-4, Skema B: Ole Kim Hansen

Statistik	
41	kunne besvare dette evalueringsskema
18	har besvaret dette evalueringsskema
43.90 %	svarprocent: 18 / 41

1	**Skema B: Evaluering af underviser**		
1.1	**Jeg mener, at det af underviseren anvendte materiale passer til kursets faglige indhold (18 besvarelser)**		
	Helt uenig	1	5.56 %
		7	38.89 %
	Neutral	3	16.67 %
		4	22.22 %
	Helt enig	3	16.67 %
1.2	**Jeg synes, at underviseren var god til at formidle faget klart og præcist (18 besvarelser)**		
	Helt uenig	3	16.67 %
		7	38.89 %
	Neutral	5	27.78 %
		2	11.11 %
	Helt enig	1	5.56 %
1.3	**Jeg mener, at underviseren stimulerede mig til at reflektere over faglige emner (18 besvarelser)**		
	Helt uenig	4	22.22 %
		4	22.22 %
	Neutral	7	38.89 %
		2	11.11 %
	Helt enig	1	5.56 %
1.4	**Eventuelle uddybende kommentarer (18 besvarelser)**		

- Forelæsningerne blev meget relateret til træer. Det betød at mage mistede interessen og koncentrationen.
- Forelæsninger lidt rodede og svære at fange substansen af
- Det virkede som om Ole ikke havde motivation og lyst til at undervise os.
- Der gik sommetider for meget juletræ i den. Kunne godt øve sig i at svare mere præcist på spørgsmålene, og være lidt mere hjælpsom. I stedet for ofte bare at sige, at det skal man selv finde på nettet eller i bogen. Kunne eventuelt forklare tingene kort, og så hjælpe med at sige på hvilke sider man kunne undersøge det yderligere.
- Kunne godt lige bruge et matematik kursus inden dette. Selve emnet var interessant, men metoder og udregninger blev for uoverskuelige, da de involverede et helt ny emne.
  Ellers en god underviser, der fortjener at emnet gives mere tid.

14

Formulating, aligning and implementing effective Intended Learning Objectives in a pre-existing course

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Introduction

The term ‘constructive alignment’, coined by John Biggs (1996), is a form of outcomes-based education that aligns both the teaching and assessment of a course to its intended learning outcomes (ILOs). Designing a curriculum to ensure alignment between teaching / learning activities (TLAs), assessments and ILOs maximizes consistency and thereby the likelihood of achieving deeper, functioning knowledge in the students: the most desirable outcome of teaching. ‘Traditional’ university teaching, however, is typically not aligned. Norm-referenced grade measures and large classes necessitated by limited resources hinder implementation of constructively aligned courses. Additionally, courses that have run apparently successfully for many years may lead teachers to believe that improvement is not required (Biggs and Tang; 2007). This approach to tertiary level education follows the objectivist theory of teaching and learning, whereupon ‘decontextualised’ knowledge is learnt, examined and applied in what can be considered context-independent situations (1996). The role of the teacher here is simply to impart knowledge, and it is then the student’s responsibility to record, remember and apply that knowledge. This is increasingly being perceived as no longer acceptable in higher educational practice, with constructivist learning theories gaining prominence. Constructivism is based upon the learner taking responsibility for their own learning, arriving at meaning and understanding through a combination of individual and group activities which allow them to construct knowledge. Through these processes, it is much more likely that the student will engage deeper learning approaches. The learner, then, takes the central role in constructivist educational environments: the 'constructive' part in 'constructive alignment'. The teacher maintains a fundamental role in providing learning situations and tasks that enable the students to achieve this higher level understanding, acting as a 'catalyst' (Biggs; 2003): this deals with the 'alignment' aspect. The teacher/s should therefore establish a framework where TLAs, teaching methods and assessments of a course are appropriate to facilitate attainment of the intended outcomes. In effect, involvement in such a course should render it highly difficult for the student to avoid learning. Under the traditional, objectivist approaches, students tend to target their learning toward the assessment. What the average student will learn is therefore determined by the examination content and method, resulting in largely in surface learning, e.g. memorizing course material in a decontextualised manner (Crooks; 1988). Creating a constructively aligned framework where surface learning will not suffice and in fact is actively difficult to pursue is therefore highly desirable.

How can such a framework for a programme be established? Biggs (2003) describes the stages as follows:

- Define optimal outcomes of the teaching, both in terms of content and level of understanding (ILOs)
- select TLAs appropriate to achievement of the ILOs;
- implement assessment activities that reveal how well the students met these ILOs; and
- award grades.

Design and implementation of ILOs are clearly the foundation in constructive alignment, be it at institute, programme or course level, and must precede the design of TLAs and assessments (Biggs and Tang; 2007). Consideration of these aspects will form the basis of this project.

Project rationale

I 'inherited' the teaching of part of an MSc. course. I took the opportunity to re-structure the elements I was involved with (lecture, lab exercises and case studies) to try and make them coherent and aligned – with each other and with the exam. Several issues and questions were raised during this process:

- What constitutes effective ILOs?
- How can these be formulated and implemented?
- How to check whether or not the ILOs had been met.

Addressing these points leads to the pedagogical aims of the project associated with the teaching of the course:

- Design new and aligned ILOs
- Compare to existing ILOs
- Consider alignment with assessment methods.

Course description

The course in question, *Heterologous Expression*, is part of the biology MSc. programme in Biotechnology (appendix 1). It carries 15 ECTS credits over one block of full-time study. My involvement was in teaching one of the expression systems. A different system was introduced every week, with each being taught by different teachers. There were 33 students participating in the course. Overall learning outcomes for the course were as follows:

The course should enable the students to appraise different systems available for heterologous expression of a gene leading to protein production, to select the most appropriate system, and to subsequently successfully implement that strategy. The summative assessment takes the form of a 30 minute oral examination at the end of the block of study.

The programme ILOs (Figure 14.1) clearly lack specificity for directing the teaching of the elements of which it is made. As a newcomer to teaching the programme, this made it difficult for me to design my teaching and to have it align with the other elements, and, importantly, with the assessment. The existing programme ILOs in the 'knowledge' category make surface level learning demands on the students: in the SOLO taxonomy, *describe* is a quantitative phase verb which requires only that the students increase their knowledge, but do not necessarily deepen understanding (Biggs and Tang; 2007). Other verbs used in the programme ILOs in the 'skills' and 'competences' categories are *use, design* and *transfer*. These address the acquisition of functional knowledge and demand higher level understanding from the students. These ILOs provide guidance as to what should be included in the teaching of the individual elements of the programme. In order that the students should be able to *design* strategies and *transfer* theories, for

Knowledge	**Describe** the main features of *E. coli*, *Bacillus*, *S. cerevisiae*, *P. pastoris*, mammalian cell lines, *Xenopus* oocytes, *Aspergillus* and plants as expression hosts **Describe** the following parameters for the above mentioned expression systems: Expression levels, Type of post-translational modifications, Mechanisms for secretion of the product, Stability of the product, Stability of the transformed expression host, Methods commonly used for transformation, Strategies for optimization of the expression level and quality of the product.
Skills	**Use** the knowledge to design an appropriate strategy for the expression of the correct amount and quality of a given protein/peptide. **Design** a strategy for creating an optimal genetically modified expression host in relation to reduction of proteases, improvement of secondary modifications and efficient compartmentalisation of the desired product.
Competences	**Transfer** theory and principles regarding the usefulness of different organisms as expression hosts to different work situations. **Make ethical considerations** about the use of GM organisms for production of peptides and about the disease risks connected to a certain expression host.

Fig. 14.1. Programme ILOs provided in the course description for students

example, they must be able to turn declarative knowledge into functional knowledge. The ILOs of the programme elements must therefore be appropriately designed. The general theory espoused by Biggs for setting ILOs within a constructively aligned framework involves thinking 'in terms of appropriate verbs' that indicate the level of understanding and performance to be achieved. These activities can then be incorporated into TLAs and assessments, ensuring constructive alignment. The topic (*Xenopus* oocytes as a system for heterologous expression), type of knowledge (some declarative; mostly functional) and level of understanding (higher level appropriate to an MSc. course) – prerequisites for ILOs - were already in place. Biggs and Tang (2007) suggest the following doctrine:

- Choose a verb at the appropriate level of understanding / performance expected;
- Specify the topic content addressed by the verb; and

- Specify the context of the knowledge which pertains to the verb.

As there were three different TLAs (lecture, journal club and lab exercises), the teaching could be viewed holistically when formulating the ILOs. The week was structured such that the lecture came first, followed by the start of the week-long lab exercises, with the journal club in the middle. The approach taken was that learning from the ILOs set for the lecture would be consolidated into functional knowledge during the other TLAs. Thus, bearing in mind the criteria given above, the following ILOs were formulated:

1. *Describe* the characteristics of the *Xenopus* oocyte system, giving advantages and limitations
2. *Compare and contrast Xenopus* oocytes as a heterologous expression system with other strategies
3. *Explain* the role of untranslated regions (UTRs) in heterologous expression systems
4. Be able to *design* a strategy to identify and characterise novel transporters.

Drawing from the SOLO taxonomy, *describe* represents a multistructural but quantitative phase ILO, whilst the remaining ILOs seek to engage learning in the qualitative phase, both relational (*compare and contrast*, *explain*) and extended abstract (*design*). The framework of the course encouraged the conversion of passive, declarative knowledge acquired in the lecture into functional knowledge through the preparation and performance of the other TLAs.

Success of the ILOs is ultimately judged through end-of-programme assessment. Small exercises were incorporated into the teaching that enabled me to check progress and understanding. For example, an exercise in which the students had to complete a table comparing elements of different expression systems during a lengthy incubation period of the lab exercise gave an indication of the whether or not ILO 2 had been achieved. The main assessment takes the form of a 30 minute oral exam at the end of the programme. One each of the practical and theoretical exercises, chosen randomly, are discussed, and the principles expected to be understood. An overview and sound comprehension of the topics covered throughout the course should be demonstrated, and links made by the student between the different course elements are sought for. Four students randomly drew the *Xenopus* lab report, and another five drew the case studies from the week to discuss. As a prerequisite, 75% of lab reports must be completed in order to attend the final exam. This means that, in theory, students having already satisfactorily passed all lab reports at the three quarters point of the course may be discouraged from handing in reports for the remaining classes, safe in the knowledge that they are not needed in order to pass. This highlights one unsatisfactory side of the assessment procedure. Oral exams are most commonly used in the defence of a thesis or dissertation, where the examiner has already seen the work under assessment. The interactive nature of the oral assessment allows the examiners to probe the students and uncover "unanticipated but valuable learning treasures" (Biggs and Tang; 2007) and allows the level of challenge to be tailored to fit each student. They are, however, time-consuming and teacher-intensive: two teachers and an external examiner took 2.5 days to examine 33 students. The notion of setting a written exam instead has been considered and discarded by the course leaders because it was felt that the oral assessment establishes immediate and clear differentiation between top and lower grade students. It also means that the constructive alignment possible between ILOs and the assessment is reduced to generic terms: being able to explain principles, understand theories, and compare and contrast the taught elements of the programme. The average score of the students on the course was 9.2.

There should ideally be three levels of alignment present in higher education environments: graduate attribute, programme and course ILOs (Biggs and Tang; 2007). Invariably, however, there are barriers to this. Jervis et al. (2005) found their efforts to achieve alignment for an undergraduate Biochemistry degree confounded by the absence of prerequisite courses and by an almost constant organizational change of the degree scheme. In fact, a report into how high-quality learning can be encouraged in higher education funded by the U.K. Economic and Social Research Council in 2003 suggests that the "application [of constructive alignment] in practice is not likely to be straightforward" (McCune; 2003). The present programme also demonstrates some of the difficulties involved in achieving constructive alignment, such as having a large number of teachers on a course who aren't necessarily aware of what is taught in the other elements, having a pre-determined and fixed framework for the teaching, and not having specific assessment requirements.

A Appendix: Course description

Heterologous Expression - Course Description 2009/2010

Details
Department of Plant Biology and Biotechnology 80 %
Department of Basic Animal and Veterinary Sciences 12 %
Department of Food Science 8 %

Earliest Possible Year MSc. 1 year to MSc. 2 year
Duration One block

Credits 15 (ECTS)
Course Level MSc

Examination Final Examination
oral examination
All aids allowed

Description of Examination: The student will be examined in one of the practical exercises as well as one of the theoretical cases. Following there will be a discussion where the selected topics are put into context with other topics from the course.

Weight: The final examination counts 100%

7-point scale, external examiner

Requirement For Attending Exam
75 % of the reports must be approved in order to attend the final exam.

Organisation of Teaching
The course contains both a theoretical part and a practical part which are closely connected. There will be lectures as well as student presentations based on cases and journals. Laboratory work is running several days a week for 6-7 weeks

Block Placement Block 3
Week Structure: Outside schedule

Teaching Language English

Restrictions Max. 40 students (lab facilities)

Course Contents
The course will contain a theoretical part where most aspects of peptide and protein production in biological organisms will be discussed (see below). You will acquire knowledge on the variety of possible host organisms found in the different kingdoms. We will discuss the possibilities of designing and finding new suitable expression hosts.

Topics that will be covered in the theoretical part of the course: The intelligent choice of a host organism / Cloning strategies envisioned by an “in silico” multistep cloning / Promoter strength and induction / Copy number and silencing problems in heterologous hosts / Expression vectors / mRNA stability and introns / Choice of, and placement of purification tags / Stability of the product / Secretion of proteins and signal trapping / Post-translational modifications in different host organisms / Inclusion bodies and folding of proteins / Expression of membrane proteins compared to soluble proteins / Heterologous expression for production of antibodies / Expression of toxic proteins / Transient expression / Optimisation of expression level / Fermentation and large scale production.

In the practical part of the course we will work with a range of different expression organisms. These include Escherichia coli, Saccharomyces cerevisiae, Pichia pastoris, Xenopus oocytes and higher plants. We will transform them and determine the amount of produced protein, we will also discuss ways to optimize the expression level and finally prove that the expressed protein exhibit the desired function. In the practical part we will also cover a broad aspect of typical problems related to the production of recombinant protein.

Topics from the practical part of the course:
Expression and assembly of a multi subunit protein complex / The effect of alcohol and temperature on expression level / Expression of a secreted protein / Sub-cellular fractionation / Detection of post-translated modifications / The use of protein homologs from thermophilic bacteria /Yeast two-hybrid system/ Split-Ubiquitin system / Electrophysiological measurement on ion-channels/ Virus induced expression

Teaching And Learning Methods
The course contains both a theoretical part and a practical part. In the theoretical part there will be lectures as well as student presentations based on cases and journals. A practical laboratory part is running several days during most weeks. There is a close connection between the topics covered in the theoretical cases and the practical work. The course will be divided into smaller parts build upon the different expression organisms.

Learning Outcome
The production of technical enzymes as well as of peptide- and protein-based pharmaceuticals are in large scale being performed in specially designed host organisms. The aim of the course is to educate the students in processes associated with heterologous expression. The students will upon completion of this course be able to design and perform a strategy for the expression of a given gene. This includes considerations about amount, quality and downstream applications of the product.

<u>After completing the course the student should be able to:</u>
Knowledge:
-Describe the main features of E.coli, Bacillus, S.cereviiae, P.pastoris, mammalian cell lines, Xenopus oocytes, Aspergillus and plants as expression hosts
-Describe the following parameters for the above mentioned expression systems: Expression levels, Type of post-translationel modifications, Mechanisms for secretion of the product, Stability of the product, Stability of the transformed expression host, Methods commonly used for transformation, Strategies for optimization of the expression level and quality of the product.

Skills:
-Use the knowledge to design an appropriate strategy for the expression of the correct amount and quality of a given protein/peptide.
-Design a strategy for creating an optimal genetically modified expression host in relation to reduction of proteases, improvement of secondary modifications and efficient compartmentation of the desired product.

Competences:
-Transfer theory and principles regarding the usefulness of different organisms as expression hosts to different work situations.
-Make ethic considerations about the use of GM organisms for production of peptides and about the disease risks connected to a certain expression host.

Course Literature
The students will receive a collection of scientific papers together with the manuals for the laboratory part of the course.

Course Scope
lectures 24, practicals 140, Colloquia 28, preparation 103, project work 116, examination 1

15

Coordination and development of a master course with many teachers – using a "Competence matrix" for the planning process

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Introduction

Master and PhD courses at the University are often multidisciplinary or cover many scientific subjects. There may be multiple intended learning outcomes, some of which may span over several subjects. In these types of courses a high scientific level and research-based teaching is often accomplished by involving many different teachers. However, the course coordinator hereby faces many challenges in the planning and coordination process of the course.

The intended learning outcomes (ILOs) of the course have to be coordinated to supplement each other, build an overall unity, and possibly support more broad and cross-disciplinary competences with higher learning levels (according to the SOLO-taxonomy). The choice of teaching/learning activities (TLAs) should reflect not only an alignment with ILOs and assessment, but also a coordination of the contributions by the various teachers. This will ascertain that the ILOs are operational and that the course in total fulfills the ILOs with maximum learning level and minimal repetition. The highest level of understanding and structural complexity is often achieved through student centered TLAs combining several subject areas and encouraging a deep learning approach (Biggs and Tang; 2007). This requires a proper communication and coordination process involving all teachers in the planning of the course. This process is necessary in order to assure that the acquired competences and their level can be assessed.

In a course involving many teachers from different sections, the teachers will often see their individual role as being isolated assisting experts without overall course ownership. This situation may be underlined by the ongoing educational change from subject/content-determined education to competence-driven education (through definition of ILOs). They may therefore be less willing to engage (and spend time) in the coordination and development of the course and only feel responsibility for their specific ILOs and not the overall or broader ILOs of the course. It is therefore a challenge for the course coordinator to encourage the involved teachers to take responsibility and ownership in order to develop and coordinate the TLAs, fulfilling the entire course ILOs. The communication and coordination process has to be initiated and lead by the course coordinator, and must be engaging, open, constructive and time efficient.

In order to make competence-driven engineering education The Danish technical University (DTU) has employed an international engineering education strategy called CDIO (see www.CDIO.org). This strategy encourages cross-diciplinary teacher-teams to use a 'competence matrix' as a communication and structuring tool in the coordination and development of whole educations. According to the CDIO Handbook for DTU (under development; pers. com. Michael May): "The purpose of the matrix is to visualize the contribution by the individual courses to the competence objectives (ILOs) of the education as well as to visualize coherence among the courses. It thereby becomes an instrument for evaluating and adjusting the academic coherence of the courses and which competences they require and supply to each other. Furthermore, it becomes a tool for assessing and adjusting the overall flow of competences through an education, and e.g., avoiding unmotivated jumps in learning levels." The report "Kompetencer og matematiklæring" by the Danish Ministry of Education (Niss and Jensen; 2002) likewise suggest a matrix-structure to relate subjects areas to competences (see http://imfufa.ruc.dk/kom or http://pub.uvm.dk/2002/kom/08.htm).

This project attempts to use an adjusted 'competence matrix' to optimize the coordination and level of learning outcomes of a single course, covering a lot of subjects taught by different teachers. The matrix was used to structure and focus the communication during a meeting with all involved teachers. The intention was to visualize the contribution by the individual subjects (teachers) to the overall competence objectives (ILOs) of the course as well as to visualize coherences, progression of common competences, and possible repeated or untreated subjects. The matrix was furthermore expected to provide an engaging, neutral, intuitive, time efficient and focused frame for the communication and coordination process. The goal of the meeting was to encourage the teachers to take further ownership and increase their consciousness on learning level, hereby inspiring to improvements and pinpointing necessary adjustments of TLAs, specific and common ILOs (and their mutual alignment).

The specific master course has no assessment of students, except for active participation during the course. However, formative feedback is provided consistently throughout the entire course and after specific student activities. There are only 16 students allowed on this course (limits set by the space on the research vessel), which allows especially the primary teacher (course coordinator) who is present during most of the course to have a very detailed comprehension of the acquired competences of the individual students. Furthermore, an additional course evaluation was this year performed by the students on alignment of TLAs and acquired competences. This was achieved by letting them fill out the same matrix, marking which of the ILOs they had acquired, during which part of the course.

The course has run for many years under various forms and locations with different course coordinators, but some consistency in ILOs. The course coordinator is newly appointed, but has been allowed to markedly influence the course coordination throughout the last couple of years, assisting the former coordinator. Therefore the main ILOs and TLAs (and logistics) had already been developed by the author and others through several years of practice. Additional ILOs and adjustments of former course ILOs were suggested by the author in a former assignment this year during the higher education teaching course (“adjunktpædagogikum, KU”). These ILOs were included in the ‘competence matrix’ beforehand and at the meeting with the other teachers the matrix was mainly used to focus on alignment, additional TLAs and learning level. However, the matrix could as well be used as a tool for developing new courses.

Material and methods

Course

The course “Marine Faunistics – biology and diversity of marine fishes and invertebrates” is a one week intensive internee master level summer course taking place at a marine biological research station in Helsingør, Denmark

(Section for Marine Biology (MBS), Department of Biology, University of Copenhagen). The course includes field work and collecting of fresh material every day (either with a research vessel or from the beach), exploring the various marine biological collecting and processing techniques. The collected material is examined in the field and/or is brought back to the laboratory for further study and identification. Theory on the various marine groups and group work on various relevant subjects and overall perspectives takes place in the field as well as the laboratory facilities. The course is run by one primary teacher (the course coordinator, author), present most days, and seven additional teachers (from MBS and the Natural History Museum, University of Copenhagen) that each teach from a few hours to up to two days during the course depending on their area of expertise and its treatment in the course. The course involves extensive logistics and many different intended learning outcomes, some of which are cross-treated or build up over several days. The collecting and processing of samples often provide material useful for several different subjects during the course, why an optimal coordination of logistics, subjects and learning outcome is crucial. The primary teacher secures this organization, coherence and continuity during the course.

Competence matrix

A new method or instrument, a 'competence matrix' was used in the coordination and developmental process during planning of the course this year. The matrix was made so that the course ILOs were presented as row headings and each course day (= subject area) as column heading (see Appendix 15.1).

An additional evaluation by the students of the constructive alignment of intended learning outcomes (ILOs), teaching learning activities (TLAs) and acquired competences was performed by filling out the same 'competence matrix' with marks for acquired ILOs.

Results

During a meeting with all course teachers, everyone commented in the competence matrix (Figure 15.1) on their covering of ILOs and indicated their predicted learning level: increasing numbers 0-5 according to increasing learning level, following the ranks of the SOLO taxonomy (see Biggs and

Tang 2007). Ownership, development of TLAs in order to maximize learning levels and achieve ILOs, as well as phrasing of ILOs and operational TLAs were discussed. A few missing teachers filled out their part of the matrix afterwards.

A few additional challenges were discussed during the meeting:

1. Very different backgrounds and qualifications among the students. Suggestion: more group work implemented in the TLAs, constructing the groups with students possessing different qualifications.
2. Last year students warranted even more activating and independent problem solving (despite the time consuming collecting and identification in itself should be experienced as activating, and three major student assignments including presentations (Tuesday, Friday /Sunday,) were already incorporated last year). Suggestion: more time during three assignments to perform independent problem solving, student presentations, further institutionalizing by teacher and formative feedback – to make students realize their actual achievements.
3. How to limit lectures and at the same time secure common high level of qualification before practical work. Suggestion: encourage literature study before course start, and more theory delivered during practical work – not lectures.

The ‘competence matrix’- meeting with the teachers resulted in very focused suggestions for adjustment of the course. During the course this summer all teachers were very engaged, well-prepared, incorporating their knowledge on the intended learning outcomes of other teachers in their own TLAs to achieve their own ILOs and support the common ILOs. Several teachers had adjusted their lectures to a more appropriate level and length, and some had prepared new student centered TLAs to fulfill the ILOs and higher learning level (hereby also including more group work and activation of students).

In addition to the more broad evaluation scheme filled out by the students every year the students also filled out the ‘competence matrix’, setting a mark for achieved ILOs under specific course days (number of marks indicated by shading in Figure 1). This additional student evaluation showed an overall satisfying alignment of ILO and TLAs and an interesting congruence with most marks for the student centered TLAs, implementing a deep learning approach. Furthermore, minor necessary additional adjustments of the ILOs were pinpointed through this written evaluation in combination with an oral evaluation.

Afterwards the answers of the common course evaluation scheme were compared with the results of the previous year evaluation. The adjustments performed had clearly improved the evaluation of the course, even for a course already positively evaluated the previous year. This year the course was highly praised for the organisation, coherence and good balance of different types of TLAs. The students further recognized the exceptional good working spirit and atmosphere of the course. It was also the impression of the course coordinator that the students were more engaged and conscious about their own acquired competences this year.

The improved logistics, organisation and coordination of the course this year can, to a large degree, be related to the optimized planning process employing the ‘competence matrix’-meeting with the other teachers. Any type of meeting involving all teachers would of course have improved the coordination and planning of the course, but the use of a ‘competence matrix’ might have caused the high efficiency, focus and easy development of new improvements achieved through a single meeting.

Conclusion

A ’competence matrix’-meeting is definitely recommended as a tool for structuring the coordination of courses with many different teachers, ILOs and TLAs. However, to obtain full value of the information gathered it is suggested to specify the ILOs and TLAs as much as possible, and further than what was done in this project. In addition, the matrix was useful in engaging and inspiring the involved teachers as well as supporting the course coordinator in handling an otherwise possibly delicate discussion on the TLAs of other teachers. The matrix may prove even more useful for building new multidisciplinary courses, involving many teachers.

Course day/ Subjects/ TLAs: ILO (in Danish):	Pre-pared	Mon: Fish & parasites	Tue: Fish	Wed: Crustacea/ Plankton/ Sand habitat	Thurs: Mollusca/ Epifauna	Fri: Annelida/ Mudd habitat/ Quant. study	Satur: Meio-fauna/ Tree of life	Sun: Student present./ Eval-uation	Lear-ning level: (only teach-ers)
ILO 1: beskrive de største benthiske, pelagiske og parasitiske dyregruppers morfologi, biologi og taxonomi		3	3	3	3	3	3	3	0
ILO 2: kunne relatere ILO 1 til evolution		2	2	2	2	2	5		1
ILO 3: kunne relatere ILO 1 til bundtype (miljø).		3	4	3	4	3	2	5	2
ILO 4: artsbestemme danske marine fisk samt individer tilhørende de største danske marine bentiske inv.-grupper		5	5	5	5	5			3
ILO 5: opnå indsigt i de største marine dyregruppers fylogeni og evolution		1	1	1	1	1	5		4
ILO 6: Opbygge metodekendskab til indsamling af danske fisk og bentiske og pelagiske invertebrater		3	3	3	3	3			5
ILO 7: anvende teknikker til indsamling og ident. af marin meiofauna				3	3	3	5		
ILO 8: anvende teknikker til indsamling og ident. af holo- og meroplankton				5					
ILO 9: vurdere hvilket redskab bør anvendes på vilkårlig bundtype til vilkårlig faunaindsamling.		2	2	5	2	5			
ILO 10: skelne kval./ kvant. redskaber & ident. faunaundersøgelsers kvant. & redskabsmæsige udfordringer						3		5	

No. of students that marked they achieved this ILO during spec. TLAs (max. *14*)	*0*	*1-4*	*5-8*	*9-12*	*13-14*

Fig. 15.1. Competence matrix. Numbers indicate learning levels (the higher number the higher learning level, following the ranks of the SOLO taxonomy) predicted by teachers during the meeting (when irrelevant no number is marked). Shades indicate number of students agreeing under the course evaluation to have achieved the ILOs during the relevant course day (the darker shade the higher number).

Part IV

Developing interactive learning environments

16

New teaching and learning activities in Biomedicine

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Introduction

We have over the last four years taught a course in biomedicine (module 1) which is a course in advanced molecular genetics for veterinary master students. Biomedicine, module 1 is part of the differentiation in biomedicine which is one of the four branches in which veterinary students can specialize during the last two and a half year of their studies. Approximately 25 students normally attend this course.

The course is designed to provide the student with an understanding of the general theoretical and practical possibilities in working with pro- and eukaryote genomes and it also concerns principles related to molecular pathology and diagnostics (Appendix A).

The course consists of three weeks with lectures and theoretical exercises followed by one and a half week with laboratory exercises (Appendix B). The lectures have until now generally been of a classical form. That is, students have prepared for the lectures by reading and a teacher expounds the subject in the class room. Lectures have of course been open for questions and discussions but in general there has not been done any extra effort to encourage this in practice.

The laboratory exercises have been made up as four different cases reflecting normal tasks and challenges in our laboratory. Every case runs over several days and gives the students opportunity to work with a number of different standard laboratory techniques for molecular genetics. Every day during the period with laboratory work begins with a briefing about the days work and the techniques to be used. The students are divided in two groups for the work in the laboratory and the teacher is assisted by a laboratory technician. The small group size makes a good opportunity for the teacher to asses for each student the theoretical knowledge and the practical application of this knowledge in the laboratory work. Hence, these exercises enable us to evaluate the quantitative outcome of lectures through dialogue and discussion with the students, and the qualitative outcome of their learning can be estimated by observing their ways to deal with cases and specific problems in the laboratory. Their written reports on the laboratory exercises should reflect both the quantitative and qualitative outcome of the combined theoretical and practical teaching.

Description of the problem

One of our experiences from the laboratory exercises has been that the students have a quite limited understanding of different basic techniques. One such technique is the polymerase chain reaction (PCR) which is a fundamental part of many analyses in molecular biology. The theoretical background for this technique is covered in the lectures and is thoroughly described in the textbook for the course. Still, we have found that many students find it hard to explain the PCR technique and its use when they get to laboratory. When they use the technique in the laboratory they often just follow the protocol without reflecting on the rationale. Troubleshooting forms a special problem, for example when the students don't get the expected outcome of the reaction. Then the student has to analyze, argue and conclude and almost no student has been able to do that properly in the previous years.

Aim

In the following I will try to analyse why the learning outcome has been limited and how we can improve the teaching and increase learning outcome of the theoretical teaching of the PCR technique. I will describe an alternative plan for the lecture on PCR and I will evaluate the actual execution of this plan as the course was running in March 2009. Finally, I will evaluate the effect of the new teaching and learning activities based on discussions with students in the laboratory and on their written laboratory reports.

Analysis of the existing problem

The course is generally burdened by a large curriculum, where the students have to read up to three chapters for one day and in two weeks they get through 500 pages of a text book at an advanced level. The large curriculum is a huge challenge for both the students and the teacher. For the student the many pages leave them with insufficient time to go in depth with the material. Teaching in the block structure, where the students focus on one course over four weeks may even intensify this problem. The students do not just have three long chapters for one day they have two big chapters again tomorrow and again the day after. New information is coming in such a pace that it can be almost impossible for the student to keep up with it. This is of course frustrating for the student and it strongly discourages a deep approach to learning.

For the teacher the great challenge is to enable the student to cope with the curriculum in a constructive way. There is an overhanging danger that coverage will be emphasized at the expense of depth. The teaching can easily end up in transmitting information by quickly going through a number of bullet lists. This will further encourage surface learning by the student. In the worst case this may even destroy interest in the topic even for the student who from the beginning was motivated and interested.

I think this is a fundamental problem for the entire course which also concerns the teaching and learning about the PCR technique. But it is also a problem which has all along been recognized by the teachers and they have dealt with it. However, I think it is fair to say that the teachers' ways of dealing with this problem have largely been focused on what the teacher should do in order to give the students the knowledge they should have. Focus has been on what the teacher should do to make the teaching as effective as possible. Different teachers have done great efforts to clarify the topics, to make power point slides illustrative, precise, concise and interesting. They have done everything they could to keep the attention from the students and to keep the lectures from getting boring. However, in all this, focus has been on what the teacher should do and the student has been left as a passive listener. Any active participation of the student has been on the students' initiative, in the way that questions and dialogue has been welcome in the class. But only very few students take such an initiative and it quickly dies out when it is not encouraged and nourished by the teacher. The result has been a one-way communication of a very good quality but at a high speed and with the student as a passive receiver of information.

This has not supported a deep approach to learning by the students. This is a serious problem in the teaching of PCR technology and a likely cause of the limited learning outcome in this topic in previous years.

Key-points for improvement

The question is now: What sort of teaching would best help the students engage the learning activities that could lead to the intended learning outcome? In the following I will focus on three factors which I think are key-issues in a solution to this problem. These are 1) motivation, 2) a good and positive teaching and learning climate and 3) student activities which can support deep learning. I will focus exclusively on the teaching covering the PCR technique. I will describe the intended learning outcome of this lecture and I will give my suggestion for how teaching should be performed and at the same time describe arguments for and the rationale behind the chosen teaching and learning activities.

This year's course in Biomedicine Module 1 is attended by 24 students. All of them have had a course in basic genetics where PCR has also been touched upon. It is two years since they had this course. They normally have no practical experience with laboratory work.

Intended learning outcome and criteria for evaluation

My definition of the intended learning outcome from the lecture on PCR techniques is that:

- The students should understand how PCR is a method to explore DNA.
- The students should be able to describe all central elements of the technique and be able to design a set of primers for a specific PCR given a DNA sequence.
- They should comprehend the logic of the polymerase chain reaction and be able to explain each step in the reaction and its outcome.
- When presented for different cases where the PCR went wrong they should be able to apply their knowledge in troubleshooting and give suggestions to correct the reaction. In doing this they should relate to the principles and reflect on the knowledge they have obtained during the lecture.

I will not use the final exam of the course to evaluate the learning outcome of this lecture. Instead I will use questions and dialogue during the laboratory exercises and the written reports on the exercises. In the laboratory the students will perform PCR a number of times and almost all of them will at least once end up with a PCR that does not work correct – experience tells us. In this way the task to be assessed is aligned with the intended learning outcome.

Proposal for an alternative teaching plan

I will begin the lecture with an institutionalization by giving examples of usage of PCR in various "real-life" situations from our own laboratory. By this I aim to give the students an idea about why the technique is used and how widely it is used in solving very different problems. Setting the stage of the lecture and motivating the students for learning are the central points here. My goal is to motivate the students by illustrating the value and usefulness of the knowledge they are about to receive. By connecting to everyday situations from the laboratory I also want to bring the topic "down-to-earth", thereby give the students the feeling that this knowledge is achievable. I want to give the students the expectation that they can have a successful learning outcome of the days lecture.

After this I will start with the broad picture mentioning different methods to explore DNA. I will then focus on the PCR technique by briefly telling about the invention of the technique. I will try to asses how much the students remember about PCR from previous courses / basic genetics. I will do this by simply asking the class to tell me anything they remember. I will emphasize that independent facts are ok. This is a very important step in the lecture. The students' answers will tell me at what level I shall continue.

After this I will give a quick overview of the reaction. This should work as a map with milestones, a map the students can relate to when we afterwards go through each step in details. This overview should give the student an idea about where we come from, where we are and where we are going as we go through the details. I think keeping a clear line in the lecture and a clear goal is very important in order not to discourage students from participating in their own learning.

Next I will describe details about each component and each step in the reaction. I use the same figure for illustration for both the overview and the explanations for details, and as I go along I mark the current point on the figure with a red frame. During my exposition I will try to involve the students with questions and make clear that there is room for their questions to me.

After this theoretical exposition of the technique I will encourage the students to engage more actively in their learning of the subject. I will do this by presenting two cases, one where the students get a DNA sequence with a target region indicated and another where they get two gel pictures with the result of a PCR reaction.

For both exercises they are to work in groups of three to four students. The groups will give each student a possibility to contribute with different fragments of knowledge of which the group hopefully can make a good combined solution to the problem. In doing this the students will reflect on the theoretical knowledge they just learned and through discussions they will have a chance to catch misunderstandings and help each other to a more correct and deeper understanding of the subject. In applying the theoretical knowledge on the case the students will explore the potential usefulness of what they learned. This will hopefully help the students to let the knowledge settle in their mind in a well ordered way.

In the first case the students should select a pair of primers designed to amplify the indicated region. The main challenge here is to get the orientation of both primers right.

In the other case pictures of gels are handed out on prints. On one of the pictures there is a size ladder but no PCR product, on the other there is smears of DNA coursed by unspecific amplification. I ask the students to select one of the pictures and discuss what they see, and what possibly went wrong. A picture of a gel with the product of a successful PCR is shown on a power point slide.

While the students are working on the cases I will go and ask different groups to come to the blackboard later and give their suggestion for a solution for a specific part of one of the cases. In this way they can prepare themselves and I won't have to wait for volunteers.

Specific improvements

What I will generally aim at in this lecture compared to previous years' lectures is to supply the students with activities that can support a deeper approach to learning. These activities are:

- I will encourage the students to ask questions and engage in discussions whenever they need.
- I will try to involve the students in describing and discussing each step of the PCR in order to help them memorize and understand key events in the reaction.
- Most importantly we will work on cases where the students will have to apply their knowledge, integrate, analyze, argue and conclude in order to plan a hypothetical repetition of a PCR experiment.

Additionally, I will make an effort to motivate the students by illustrating how the day's topic is of importance in solving many different problems in our own lab, i.e. in a world where they may see themselves in a few years time. By referring to our everyday life I will also try do de-mystify the subject to make the students see that understanding of this subject is achievable and obtainable with just a little effort from them.

A few reflections after giving the lecture

The lecture was given in March 2009. Seventeen students meet for the lecture.

When I ask to their background knowledge about PCR, before I start my own exposition of the subject, I get a good response from three students. One student makes a minor mistake by referring to a primer as a probe. I correct this nice and easily. We already have a good atmosphere where students can make mistakes and learn from them without feeling embarrassed. Responses from the three students indicate that I have a good foundation to build on in today's lecture. However, I don't know if the rest of the class has the same understanding. A better way might be to ask all students to write down at least one fact about PCR and when all had done that they could read it up.

Even though I try to involve the students in the detailed description of PCR, this part easily becomes the long and tiresome part of the lecture.

I involve the students in discussing the steps of the temperature cycle of PCR. There is again good response and a fruitful atmosphere. Input from the students gives good points to elaborate on.

The first case about primer design is working well. There are good discussions in all groups. I can see that almost all groups have problems with the orientation of the forward primer. Because it seems to be a general problem I leave this to be discussed in plenum when a solution is presented by a group. The presenting group does well but they have got the orientation of the forward primer wrong. I show them how their primers will anneal and let themselves identify the problem. Within a few moments they correct their mistake and make a primer with the right orientation.

There are a lot of good suggestions about what went wrong in the cases with unsuccessful PCR, from both the presenting group and from the class. The students only miss one point namely low annealing temperature as a cause of unspecific amplification.

Assessment of learning outcome

The learning outcome from the lecture on PCR technique was assessed through questions and dialogue with students during the practical laboratory exercises two to four weeks after the theoretical part of the course and via the students' written reports.

The students are divided in two groups for the laboratory exercises. During the exercises the students are taught by a teacher assisted by a laboratory technician. I taught one of the groups while a colleague taught the other. Hence, I follow one group closely. For the other group I try to mingle as much as possible in the lab, listening to their discussion, observing their approach to the work, and occasionally asking questions. The same technician participated in teaching both groups.

As expected almost all students encounter problems with a PCR at least once during the laboratory exercises. Their problems are equivalent to the case with different pictures of gels with unsuccessful PCR products. By evaluating how the students deal with these problems it appears that the obtained learning varies quite a lot between them.

A few students clearly just want to get the exercises done as quickly as possible. They are clearly not motivated for learning and they have a surface approach to learning during the practical teaching of the exercises. These students do not want to put much of an effort into finding the cause of their missing success. In dialogue and in the reports these students demonstrate a lack of understanding and some basic elements and key events are misunderstood. Interestingly some of the students who perform worst are two of the students who initially gave good response during lecture, when I asked to the students' background knowledge on PCR before my teaching.

Other students do an effort when they are asked for it and a few students engage the task with great enthusiasm. They all demonstrate that they remember facts about the different components and steps of the reaction and they are to different degrees able to integrate their knowledge with their actual results and identify possible problems. It is clear that it is a bit hard to recall right away what they learned two to four weeks ago but still, they know they have the tools to solve their problem, they just have to find them again when they suddenly need them.

Discussion and conclusion

Two to four weeks passed between the lecture and the laboratory exercises. This clearly made it difficult for many students to make the same trouble-shooting on their own unsuccessful PCR as they had made in the case during the lecture. Given the large curriculum and the volume of information they had met since the lecture this was indeed expectable. That the majority of students could actually deal appropriately with the task during the laboratory exercise indicates that the learning outcome of the lecture was good. According to the laboratory technician, who has followed the course over several years, this was also improved compared to previous years.

During the laboratory exercises the class was divided in two. One group was taught by me and the other by a colleague. My colleague repeatedly complained that her group lacked motivation. This was not the experience with my group. Why it was so, is hard for me to account for but the lack of motivation on one team certainly affects the engagement in troubleshooting and hence gives a bad impression of the students learning outcome from the lecture. Hence, it is to some degree a question if the learning outcome from the lecture was poor or if the conditions for evaluating the learning outcome were not optimal for one of the groups.

Some of the students who in the lecture demonstrated good background knowledge about PCR actually performed worst during the exercises. These were two foreigners who had their bachelor degree from other universities. Their good response regarding previous knowledge indicates that they probably learned more about PCR on their basic courses than our own bachelors. I am afraid that this might have given them the impression that they already knew enough about the day's subject so that there would be nothing to gain from engaging actively in learning during the lecture. This might have been prevented if I had stated the intended learning outcome more clearly in the beginning of the lecture; thereby making them aware what they now had a chance to build on a new layer in their knowledge about

PCR. Their good background could be used in a positive way to point out that they actually were in a first class position to learn more.

The majority of students were able to deal with PCR problems in a way that demonstrated a good level of understanding of general principles and ability to apply this knowledge into a practical solution of a specific and real problem. This level of understanding was an improvement compared to what we have seen in previous years. Hence, it seems that the teaching and learning activities in the theoretical exposition of the PCR technique have had a positive effect on learning outcome.

Now, what could still be improved? As stated above, going through the details of the PCR easily becomes a tedious part of the lecture. Still, this is an important part of the learning objectives. Hence, this part should receive more attention. It is important that the students engage actively in learning this part, and we need to stimulate new activities to facilitate this.

In conclusion the new teaching and learning activities in this year's teaching in PCR techniques had a positive effect on the obtained learning for a majority of students. However, improvements are still possible for example in motivating students by making clear that there is a potential for advancement in knowledge even though you may have good background knowledge. Also, there is still room for many more activities which could support learning with a deep approach. The large curriculum to be covered in a short period is a great challenge not only for teaching of the PCR technique but for the entire course. Therefore, the problem that we have been dealing with here is probably a general problem for the entire course and the total learning outcome from the course might be improved if changes similar to those described here for the teaching of one specific technique were considered for all topics in the course.

A Appendix: Part of the Course description

Part of the course description

Source: http://www.kursusinfo.life.ku.dk/Kurser/300056.aspx

Biomedicine, module 1 - 300056

Course Description 2009/2010

Please note: Course Description 2008/2009 is also available.

Overview:

1. Details
2. Areas of Competence the Course Will Address
3. Course Objectives
4. Course Contents
5. Teaching And Learning Methods
6. Course Scope

Course Contents
The course provides the basis for understanding the general theoretical and practical possibilities for working with pro- and eukaryot genomes and products from these. Furthermore, the course provides a basis for understanding the general principles related to molecular pathology and diagnostics. The course is based on "state-of-the-art" molecular biological techniques and it provides an introduction to Bioimaging and sophisticated use of microscopy.

Teaching And Learning Methods
Lectures, cases, theoretical and practical exercises.

Learning Outcome
Learning Outcome
- Describe the structure and function of the mammalian genome
- Describe the structure and function of the prokaryote genome
- Summarize the main issues in relation to genetic mapping of qualitative and quantitative traits in mammals
- Summarize the main issues in relation to identification of mutations that are responsible for diseases in mammals
- Describe the main molecular biological methods that are used in relation to research

within the area of pro- and eukaryote genomics
- Perform the basic molecular biological techniques used in relation to research within the area of pro- and eukaryote genomics
- Understand and provide a critical evaluation of literature describing basic molecular pathological problems

Skills
- Evaluate which molecular genetic techniques are relevant for the study of a given genetic problem
- Evaluate the result of a sequencing analysis
- Perform basic annotation of sequence information
- Analyse and evaluate results from simple diagnostic tests in mammals
- Analyse and evaluate results of parentage tests
- Analyse and evaluate results of expression studies
- Be able to discuss professional and scientific problems in relation to molecular pathology both with colleagues and non-specialists

Competences
- Be able to find new information/literature on topics within the area of genomics
- Be able to take responsibility for own professional development and specialization within the area of molecular biology

Mark 12: A student that has passed the exam of the course with mark 12 must have answered all sub-questions within each of the 5 questions satisfactorily .

B Appendix: Teaching plan – theoretical and practical parts

Teaching plan, theoretical part

Dif. Biomedicin, valgmodul 1, teoretisk del

Dato	Ca. tid	Emne	Form	Literatur*	Lære
Mandag d. 2/2	9-10	Intro to course and brush up			-
	10:15-11 11:15-12	Intro to Exercise 1 Genes in pedigrees	Results in report Lecture	 Chapter 4	-
Tuesday 3/2	9-11 11:15-12	Analyzing DNA	Lecture	Chapter 5, 6 & 7	-
Wednesday 4/2	11:15-12 13-14	Genome projects and organization of the mammalian genome Paper for group work (Exercise 3)**	Lecture Results in report	Chapter 8 & 9	-
Thursday 5/2	9-11	Gen expression	Lecture	Chapter 10	-
Friday 6/2	9-11	Comparative genomics	Lecture	Chapter 11 & 12	-
Monday 9/2	9-12 12:30-15	Identification of disease genes: simple and complex traits Exercise 2	Lecture Results in report	Chapter 13, 14 &15	-
Wednesday 11/2	9-11	Molecular pathology/cancer genetics	Lecture	Chapter 16 & 17	-
Friday 13/2	9-10 10:15-11	Genetic testing Beyond the genome projects	Lecture Lecture	Chapter 18 Chapter 19	-
Monday 18/2	9-15	The microbiology genome; phylogenetics; transcriptomics	Lecture		-
Tuesday 19/2	9-9:45 10-12:30	Bioimaging: overview and techniques Immunocytokemi and fluorescensmikroskopi	Lecture Lecture		-
Wednesday 20/2	9-11 12:30	Transmisson electron microscopy Manipulation of cells and animals	Lecture Lecture	 Chapter 20 &21	-
Thursday 21/2	13-14 (H1) 14-15 (H2)	Confocal laser scanning microscopy	Demonstration§		-

Teaching plan, practical part

Week 1

	Monday 16/3	Tuesday 17/3	Wednesday 18/3	Thursday 19/3	Friday 20/3
9:00-12:00	**Introduction to the practicals** (MF) **Briefing** (PKM/SCS) **Personal presentation** **Safety** (TNM) **Labtour** (TNM, MMJ) Extraction of DNA (A.1)	**Briefing** (PKM/SCS) Extraction of DNA(A.1) OD (A.1) PCR(A.2) cDNA synthesis (D)	**Briefing** (PKM/SCS) Cleaning PCR product (A.3) OD (A.3) Ligation (A.3) Transformation (A.3)	**Briefing** (PKM/SCS) PCR paternity (B) Count colonies (A.3) Set up o/n cultures for miniprep (A.3)	**Briefing** (PKMSCS) Miniprep (A.3) OD miniprep (A.3) Digest miniprep (A.3) Gel electrophoresis (A.3)
12:00-12:30	Lunch	Lunch	Lunch	Lunch	Lunch
12:30-16:00		Gel electrophoresis (A.2)	Plating (A.3)	Run PCR in ABI3130 (B)	Sequencing reaction (A.4))

Week2

	Monday 23/3	Tuesday 14/3
9:00-12:00	**Briefing** (PKM/SCS) Precipitate DNA sequencing reaction (A.4) Sequencing run on ABI3130 (A.4) PCR on somatic panel (C)	**Briefing** (PKM/SCS) Run agarose gel/analysis results (C) Sequence analysis (A.4) Discussion of results (A,B,C) (PKM/SCS)
12:00-12:30	Lunch	Lunch
12:30-16:00	qRT-PCR (D) Analysis of Paternity (B)	Analysis of qRT-PCR results (D) **Theoretical background and demonstration:** blotting techniques (SCS)

17

Improving the Lecture Format

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Introduction

This project is about improving the lecture format, to improve learning of students during the class. This implies also introducing more activation during the class. Another focus during this project is in improving the final assessment, by ensuring better alignment with the lectures and activities learning goals. I use my block 3 course on experimental nuclear and particle physics for this (see description in practical part, page 211). It is the first time I am officially responsible for the course so this allows me to take some decisions about improvements of the course. To verify how well the goals of this project have been met, at the end of the course the students will be asked their opinion about this more "active" approach to teaching via an anonymous questionnaire. The students' performance at the final exam and my personal impressions on the exam will be used as well.

During this project, the support and advice received during the supervised sessions by the department and educational supervisor have been invaluable, and have improved significantly my teaching methods and my view on teaching. I would like to thank Bob and Jens for this.

Theoretical part

Having responsibility for a course is rewarding and challenging. As one says: "With great power comes great responsibility". Several months before the course starts, the basis of a good work with the course have to be laid down, by writing very clearly what are the Intended Learning Outcomes (ILOs) of the course, and what the specific content of the course (the curriculum) should be. One could say that this project really started when I had to write down the description of the course, and this really drove the whole design of the course (activities, exam, curriculum ...).

Once the ILOs are clearly formulated, the next step is how to do the teaching, so that the ILOs can be achieved and the students learn what I want them to learn. The success of the last step in the course, the exam, is extremely connected to this second step, and therefore I felt that the exam should also be part of the project.

Although the course comprises both lectures and laboratories (addressing declarative and functioning knowledge respectively), I will devote my effort in this project to the lectures, so development of declarative knowledge. It is mainly declarative knowledge that is tested during the final exam too. Functioning knowledge is mainly assessed during the laboratory exercises itself and during the students presentations of their laboratory exercises results, although some questions regarding functioning knowledge can be asked during the final exam too.

I will start with a review of some theoretical ideas about how teaching can be improved. The main inspiration has been “Teaching for quality learning at university”, by J.Biggs and C.Tang, and various literature referenced in it. These ideas have been the guiding lines for the improvements I have tested during my course, as described on page 211 onwards.

Teaching/learning activities for declarative knowledge

In my own words, a student has a good declarative knowledge on a subject when he/she has acquired a deep understanding of a subject, and is therefore able to explain it clearly to others both at a simple level (to non-experts) but also at a deep level (to experts in the field). As an example, in my course about detector devices for elementary particles, a student with good declarative knowledge should be able to explain the basic principles of a detector for elementary particles, but also elaborate on the pros and cons of the design of a particular detector described in a scientific report. This is basically the ILO for declarative knowledge I set for my course.

The situation where the students acquire declarative knowledge is typically denoted with the name “lecture”. Most often a lecture is identified with a method of teaching, where students listen and the teacher talks. This is not really optimal for learning. A lecture should instead be seen as a situation where students are learning, using different methods or activities (Biggs and Tang; 2007, pp. 104–134). To improve lectures, the following points are important:

1. Lectures are to be seen as situations in which different teaching / learning activities (TLAs) can be organized, according to the ILOs of the course. This will keep the mind of the students active and engaged in what they are being taught, and therefore help them learn it for good.
2. The focus of a lecture should be on what the students are doing. A teacher should constantly study its class, and according to its size and composition, understand how students are best activated and engaged in the subject, and whether they are learning or not.

The motivation is simple, although apparently difficult to recognize by many (me included): people do not really learn something, unless they have really tried to understand it their-selves first, in an active way (not just listening) and unless they think it is relevant to them (the last point will be taken up again in the next section).

Alternating activities during a lecture, as opposed to long monologue lectures, has also to do with the way we learn. Studies show that effective learning dramatically decreases after 10-15 minutes, and that a rest or change in activity roughly at this time interval will bring the effective learning up to its full power. The long-term retention of concepts covered during a lecture is also dramatically increased if some review happens at the end of the lecture. Various examples of TLAs are suggested in (Biggs and Tang; 2007, pp. 104–134), some of which I have picked up for this project, as described in the practical part (211).

An advantage in small classrooms like the one I describe for my course below, is that they can easily become very interactive, so that the lecture really becomes a conversation. The teacher needs to be ready to answer basically any question, and sometimes improvise if a new point of view is brought up in the discussion. So this type of lecture can be extremely inspirational, and students can learn tremendously, but the teacher needs to prepare for this. The teacher gets also enormous feedback about the students' level of understanding during such interactive lecture. It is also very important for engaging students in learning during a lecture, and actually one of the basic principles of University teaching, that lecturers bring in their own research experience and bring to life the subjects that are being taught by putting them in the context of current research in the field. This adds invaluable content to what the students learn during a lecture.

Assessment

It is a well-known fact that what students decide to learn during a course is largely driven by the knowledge required at the exam. Therefore, if a course has some ILOs, then the best way to ensure that students will achieve those is by focusing the final exam format and content around those, making this clear to the students during the course. This is a very powerfull way of getting them more engaged in learning activities during the lectures. Since ILOs drive the TLAs, of course, then it is clear that the TLAs used during the lectures will help the students learn and prepare for the exam at the same time.

Should one try to assess students' level of knowledge and understanding during the course, before the final exam (when it could be too late)? The answer is yes, absolutely, as long as it is seen as giving/receiving feedback rather than a judgement (Biggs and Tang; 2007, pp. 163–194). It is especially valuable to the teacher, to get feedback about the status of the students' learning and eventually tune the teaching method and the lecture content. In a small class like the one I have, this can be achieved by encouraging questions during the lecture, or going from group to group during problem solving and answering questions.

Another point regarding the exam worth further consideration is how grades are assigned. A method of assessing students which is in line with the course and activities and more fair to the students is the criterion-referenced assessment: students are assessed based on how well they have meet the ILOs specified for the course. This is a relatively new way of looking at exam grading, therefore quite interesting to test. It requires the teacher to ensure alignment between the ILOs, the TLAs in the lectures and the format and content of the final exam, of course, but it is the most fair way to assess students, in my opinion.

The final assessment requires also a good deal of preparation from the teacher point of view, before the exam starts (Biggs and Tang; 2007, pp. 163-216). Three steps should be distinguished: setting the criteria for assessing the student, selecting the evidence that would be relevant to place final assessment, making a judgement about to which extent the criteria have been met. Only by following these three steps the students will be graded in absolute (not relative to each other) and most fairly.

Practical part: Course on experimental particle and nuclear physics

Improving the lecture format

As mentioned in the introduction, this year I decided to work on improving and increasing TLAs during lectures, keeping in mind the ILOs of the course. I have 9 students (1 girl). In addition, sometimes a PhD student (girl) joins the lecture, but she is not registered for the exam. In this section I describe the improvements I tried to introduce, and the results of this, as seen from my point of view. In the final section (page 216), the opinion of the students is reported and compared to what I concluded.

Improvements on lecture layout

The course has a block structure, therefore each week one half day of lectures and one full day, divided in morning lectures and afternoon laboratories. For the project I focus on the lectures. Teaching for several hours can be very tiring both for the students and the teacher, and without any form of feedback of how much students are learning during those hours, and without any activity to challenge their curiosity and make them think about what they are learning, I believe that effective learning will be low during lectures. So for a lecture, I typically prepare for:

1. Breaks after each hour.
2. During each hour there should be at least once an activity (TLA) with the students in the form of questions, problem or exercise. Students are grouped two by two (some prefer to be alone) when they need to discuss and prepare the solution. Attention is paid on how to pair some of the students (after couple of lectures is easier, because one knows the students better)
3. Split the lecture subjects into a few self-contained parts, which fit well within the planned breaks.
4. At the beginning and at the end of the lecture, explain respectively what we are going to learn and what we have learnt, respectively. This will focus more the students, they know why they are learning what I tell them, and the summary at the end helps them cross check if they have understood or not (and eventually ask questions).

5. Point out clearly during the lecture where the material can be looked up. Lectures' slides are always available after the lecture on the course web-side (I do intentionally after the lecture because in the slides there is also the detailed explanation of the solution to the exercises or problems we do in class).
6. Always be ready to interrupt the lecture to answer questions and also to have a brief discussion with the students about a subject. During the lecture, move around and closer to the students, to welcome questions and encourage interaction.

I find that with careful preparation – needed to stay on time and at the same time cover 1.-6. – and a few trials, this organization of the lecture time helps a lot students learning. They are all very attentive, and engaged, and they also feel they are in safe hands, so to say. The class is very interactive, quite different from last year. I also feel, at the end of the class, I know how much the students have learnt, due to the interaction happening in class.

Improvements on activation during the lecture

Concerning the TLA used during the lecture, I have at least one extended activity in the form of a problem or exercise, where students work in groups (2 maximum). This lasts about an hour. During the rest of the lecture, I then use briefer activities in the form of questions (answer by raising hand for yes/no, or direct questions depending on the class mood/subject of the moment). A typical problem will look like the one shown in Appendix B. The problem is presented very briefly at the beginning of a lecture. The students are told that this problem resembles very much what they will have to solve for the exam.

Now they know the goal of what they are going to hear from me in the next hour or so: the tools, concepts, for how to solve then this problem. When the problem is then represented to them later on, they will solve it by using what I just taught them (if additional knowledge is need from previous lectures, then at least the basic formulas are reproduced on the problem sheet, as in page 5 of the example).

Students in the class are quite different, so the questions range from easy to difficult, and there are a few different ones, see problem in Appendix B, page 4: students are first asked to use a formula they just learnt in class to calculate the resolution of the tracking detector. Then they are asked to look at this number, and look at the quantity they need to measure with this detector (?z, shown in page 1 and during the lecture) and argue if this is good or not. Then they are asked to argue more generally about the layout of the detector (this requires putting more than one concept learnt in the lecture together), etc.... I think this helps learning a lot, towards the ILOs of the course, because this puts the "sterile" concepts of resolution, design etc of a detector in the context of the physics goals of the experiment, and makes them understand why they are really important. Also, due to the different levels of questions, all students will be able to answer something, and there is also something challenging for the better students. During this activity, I make sure to go around and check on every group, since solving this type of problem sparks lots of questions, which need to be answered promptly for the students to progress.

When the time to discuss the solution comes, I gather the transparencies with the answers and make sure the groups go each through at least one of their answers. I ask students to present their results using hand-written transparencies. I find this method of solving problems very useful, it puts them in charge of their own results and they theirselves like this. It also helps them learn how to explain their results. I also tend to add some concluding remarks, putting again what we have learnt in the problem in the context of current research, and giving additional relevance to the subject. Then one really sees the students' eyes sparkling...

Another type of problem proposed in class was more visual, see appendix C: students were presented with computer pictures of particle collisions from an experiment at CERN, and were asked to identify the particle types according to the information provided by the picture. Then each student would have a turn to say his/her opinion on one picture at least, and we discussed all together the reply. This problem raised a lot of discussion and questions during the lecture, and made the students during the lecture very very active and engaged.

The introduction of this problem solving activity has been very successful in my opinion, although at start not all students participated with the same level of commitment, but this has changed while we went along with the course. I think they learnt a lot this way. They learnt some of the concepts I wanted them to learn, without me telling them but simply by discussing and arguing on the problem. They also learnt better a concept described only briefly in the lecture by using it in a real problem. They learnt much more that if I had presented the same concepts, with all the answers given already.

Additional improvements

Additionally, I decided to devote two lectures "situations" to two new activities: one day trip to a modern particle physics laboratory (DESY, near Hamburg) and one half day of students' presentations of their lab results on a laboratory experiment of choice.

The trip allows to actualize, to make more concrete and real and hopefully interesting the subject of the course. Modern particle physics detectors are huge, and cannot be brought to the classroom or laboratory. So discussing them in the lectures can result a bit sterile. I believe this trip activity has been very interesting, and useful, to put concepts learnt in class into context of modern research, and all students participating in the course have confirmed this. This really fulfilled one of the purposes of university teaching, to bring current research topics into the lectures (or rather, lectures to the research place).

The presentations are useful for me (and for the students) as formative assessment on the students' level of understanding of the theory behind the laboratory exercise and on the ILO of "explaining" (declarative knowledge), which is an important part of the final exam. During one group's presentation the other students are encouraged to ask questions to them, while we teachers act as moderators and try to intervene as little as possible. The presentation in itself is also useful preparation for the exam, where students are asked to present in 15'-20' answers to the exam questions typically on an experiment's design report or scientific paper. I was amazed by the enthusiasm and the good level of preparation of each group. Peer-students posed lots of questions, and I hardly had to intervene. This activity was, in my opinion, a success.

Improving the final assessment

First of all, the format of the exam: I personally consider that declarative knowledge, involving abilities like "explain", "argue", "analyse", etc. . . is best addressed by an oral exam, with assignment and both students presenting and teacher asking questions. Oral examination is more complex – the teacher receives more inputs of different types, and needs to draw down some clear rules of how to grade what – so it needs more preparation, but is also the best in my opinion. The format is: 15'-20' of presentation of the student, on answers to a problem assigned two working days before, see appendix D. Then, questions from the teachers (me and a couple of colleagues who helped with the teaching and labs). The students have picked a problem among many (each problem is assigned a number, and they pick a number randomly), and to each problem a teacher is assigned, and he/she will then be the one starting with the questions, and only after he/she is done the other co-teachers can ask more. This should diminish confusion and fear for the student (1 against 3) , as we discuss with him/her one by one, and his attention is then focused on one person at a time.

This year I decided to test two important changes:

1. I decided that we should follow the criterium-referenced assessment, and assign grades according to which extent the student has reached the ILOs for the course. After some discussion with the collegues participating in the examining committee, we agreed on what described in Appendix E.
2. To make sure I can fulfill this quite ambitious goal of sticking to the criteria above for grading, I prepare a set of easy, medium and difficult questions on various subjects of the curriculum, so that I have them ready for the different cases. Eg. I have a student oscillating between grade 2 and 4, then I have a few easier questions to ask, to see if the student has at least read and digested to some level the curriculum or not. The difficult questions (some of them open or divergent questions) are e.g. useful in the case one is uncertain between grade 10 and 12 for a student, and wants to see if the student has acquired confidence enough to attempt an original answer.

1. and 2. allow me more easily to assign an absolute grade to the students, and to provide each student with a clear explanation of why they got the grade they got.

I think that this exam format fit quite well the course changes I implemented this year. Maybe students' presentations could be shortened, by preparing problems slightly shorter, since some students indeed went beyond the time assigned. There should always be enough time for questions from the teachers, to collect enough "evidence" to assign the grade fairly to all students. Besides this, the more careful preparation before the exam from my side, and making sure to collect enough information during the exam by asking questions with the focus of understanding how well students have really understood one subject, paid off. I felt I could assign with good confidence grades to the various students. Students scored rather high, with three 12 and three 10 and two students coming for re-exam (so still to be assigned) and one (Erasmus) who decided to return to France earlier than expected.

Unfortunately one professor moved at last moment the exam for his course one day after mine, so some students attending both felt they could not cope with exams so close in time, hence the reexam cases. This range of grades can be expected since this is a last year course, so many good students attend the course. Maybe the grades obtained are high also because students indeed learnt quite a bit during the lectures and were more ready for this type of exam. Students presentations were in general excellent, many students added material self found on the internet, and the format and depth of the explanation of the solutions was very satisfactory. My overall impression was that students acquired declarative knowledge on the subjects covered in the course at the level I had aimed to.

Feedback from the students

So far I focused on what the results of this project are (outcome of improvement of activities and exam), as seen from my point of view. But what about what the students thought of it? To gather some information, I decided to prepare an anonymous questionnaire, asking for feedback on lecture format, teaching activities, and exam preparation. I distribute the questionnaire during the second last lecture, to have also a chance to use the last lecture for additional needed explanations to students. The statistics is low (only 10 students) but some useful information can nonetheless be drawn from the answers (appendix F).

Looking at the Lecture questionnaire, one can see that students clearly believe that the lectures help them in achieving the ILOs of the course and support learning, and have enough opportunity to get feedback during the lecture, for example asking questions. It also seems that the short breaks devoted to discussions two and two are enough. The format of the presentation (with slides) is ok, but students seem to like also a more personalized format by using blackboard, probably because it also slows down the pace of the lecture, so for next year I will try to use more this as well. In general, this result matches the impression I got myself of the students' opinion, during class, so this shows that this structure of lecture was appreciated on average, and it also shows that I got the correct feedback during class.

Looking at the Teaching Activity questionnaire, one can see that students believe both exercises and problems, solved in groups, help them learning, and that the feedback (institutionalization) on the solutions to the problems are clearly covered in class. So the feedback on having this type of activation in class is definitely positive, and matches well again the impression I got during the interaction with the class. It also seems that the type and length of problems and exercises proposed is appropriate, so probably one can continue with this in the next years.

Looking at the Exam questionnaire, and remembering that this questionnaire was filled before the end of the course, one can see that students think that both the lecture slides and the book are important to prepare for the exam, confirming the results on the Lecture questionnaire, that lectures help them learn the ILOs of the course. It also seems like the student might like to do more problems similar to the exam in class (consistent still with the result in the TA questionnaire), and that they like to be able to ask further questions during preparation for the exam (something I encouraged them to do during the last lecture). One important message I got from this questionnaire, and tried to compensate for in the last lecture, is that students are not completely sure what to expect for the exam. I was a bit surprised by this, given how I had introduced some of the problems solved in class. Anyway, I devoted part of the last lecture to remind them that the problems we had in class are very similar to the exam questions, and reassuring them of the important point to focus on (in answer also to the E7 response).

5. Conclusions

The goal with this project is to improve learning during lectures and improve exam format and execution, basically introducing additional activities during the lectures hours and ensuring alignment of the lectures and exam with the ILOs of the course. Taking inspiration from the book by Biggs and Tang (2007), and reflecting on several of the points brought up in chapters 7, 9 and 10, I decided to implement some of the ideas into my course this year.

I believe that the changes I introduced during this course have been welcomed by the students, and have helped them learning and performing well at the exam. This is confirmed both by the exam results but also by the response to the questionnaire distributed towards the end of the course.

A Appendix: Course ILOs and assessment

Master level, Block 3, February-April 2009, 7.5 ECTS

Goals:
The purpose of this course is for the students to learn how subatomic particles are detected in modern physics experiments and how data from a particle detector is analyzed to measure the basic properties of subatomic particles. An introduction to particle accelerators will be given as well.

ILOs:
1. After following this course, the students have a theoretical understanding of how modern detectors for subatomic particles function, all the way from the physical processes in the detector sensors to the final energy and momentum determination of a particle.
2. know the basic principles of how to operate a particle detector and collect the data, using cosmic rays or radioactive samples as sources of particles.
3. know how to simulate data from a particle detector, or how to visualize and analyse experimental data from particle detectors, with the help of computer programs bases on C++ language.

Assessment:
The grade 12 is given to a student who at the exam has shown clear understanding of all theoretical and experimental aspects covered in the course, and in addition has demonstrated the skills listed in the ILOs above during the laboratory and computing exercises.
Students will be provided, a few days before the exam, with a publication about a recently proposed experiment, and a set of questions regarding the publication. The answer to these questions will constitute the basis of a 15 minutes presentation the students will give on the subject, on the day of the exam. The presentation will be followed by questions on the material presented, or more generally on the material presented during the lectures or discussed during the laboratory exercises.

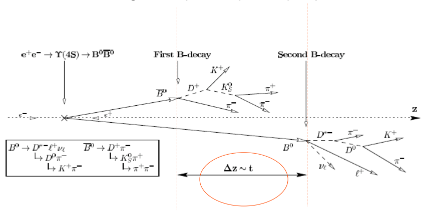
ILO nr 1. is focused on declarative knowledge, nr. 2 and 3 are focused on functioning knowledge. Laboratory sessions and reports are used for nr. 2 and nr. 3, and activity of the students in the laboratory (plus some questions during the exam) are used for assessing functioning knowledge.
The project focuses on nr. 1, and declarative knowledge.

B Appendix: Example of problem to solve in class

On the following pages is an example of a problem to solve in class.

Babar measure the amount of matter transforming into antimatter

Measuring $\Delta z = t$ precisely is very important



B0 can transform into <u>B0</u> along the way (phenomenon called mixing)

$$\frac{N_{B0} - N_{\overline{B0}}}{N_{B0} + N_{\overline{B0}}} \quad != 0 \text{ and depends on time t}$$

Babar goal is also to measure various very rare decays of B mesons
This requires extremely good momentum resolution, to clean up
the signal from background

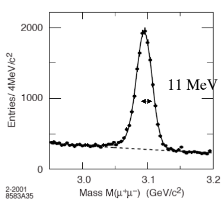
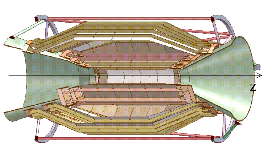


Figure 47. Reconstruction of the decay $J/\psi \to \mu^+\mu^-$ in selected $B\overline{B}$ events.

In decays like
B-> pi pi pi pi
or so, the momentum
of each decay particle
can go down to
~10 MeV
-> momentum resolution
challenge

SILICON VERTEX DETECTOR



Layer/ view	Radius (mm)	R-O pitch (μm)	Floating strips	Strip length (mm)
1 z	32	100	1	40
1 ϕ	32	50-100	0-1	82
2 z	40	100	1	48
2 ϕ	40	55-110	0-1	88
3 z	54	100	1	70
3 ϕ	54	110	1	128
4 z	91-127	210	1	104
4 ϕ	91-127	100	1	224
5 z	114-144	210	1	104
5 ϕ	114-144	100	1	265

- Given the pitch, what is the spatial resolution? And the angular resolution (roughly) ?
- Does the resolution fullfil the requirement for measuring precisely the decay distance Δz between the two B mesons?
-to measure Δz=t precisely, should we rely on all layers ?

-Use the answers before to motivate the structure shape and the number and position of layers of silicon detector.

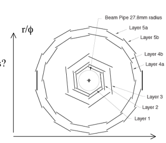
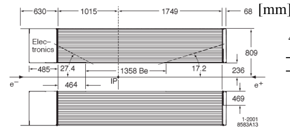


Figure 18. Schematic view of SVT: tranverse sec-

DRIFT CHAMBER



40 wires, B= 1.5 Tesla

Parameter	Values
Mixture He : C_4H_{10}	80:20
Radiation Length	807 m
Primary Ions	21.2/cm
Drift Velocity	22 μm/ ns
Lorentz Angle	32°
dE/dx Resolution	6.9%

re 28. Longitudinal section of the DCH with principal dimensions; the chamber center

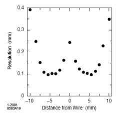


Figure 37. DCH position resolution as a function of the drift distance in layer 18, for tracks on the left and right side of the sense wire. The data are averaged over all cells in the layer.

Remember

P_T (GeV) =0.3 B(Tesla) r (m)

$\sigma_{PT} / P_T = \sigma_x P_T \sqrt{(720*(N+4))} / (B L^2)$

$\sigma_{PT} / P_T |_{ms} = 0.045 / (B \sqrt{(L X_0)})$

Does this geometry fullfill requirement on:

- reconstruct particles with $p_T^{\ min} = 60$ MeV?
  (If not, what other detector can be used for this?)
- providing momentum resolution < 1% for relevant range of B decay products ?

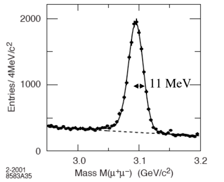


Figure 47. Reconstruction of the decay $J/\psi \rightarrow \mu^+\mu^-$ in selected $B\overline{B}$ events.

How do you calculate the mass of J/psi, if what you can measure is the two muons from its decay (assume m_muon=0) ?

How do you calculate the error on the mass of J/psi?

Justify roughly the width of the mass peak observed in fig 47

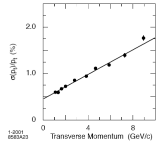


Figure 46. Resolution in the transverse momentum p_t determined from cosmic ray muons traversing the DCH and SVT.

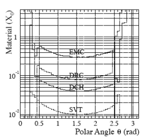
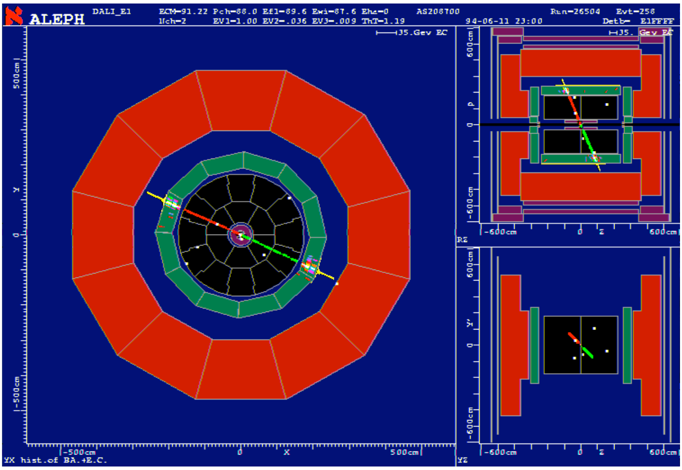


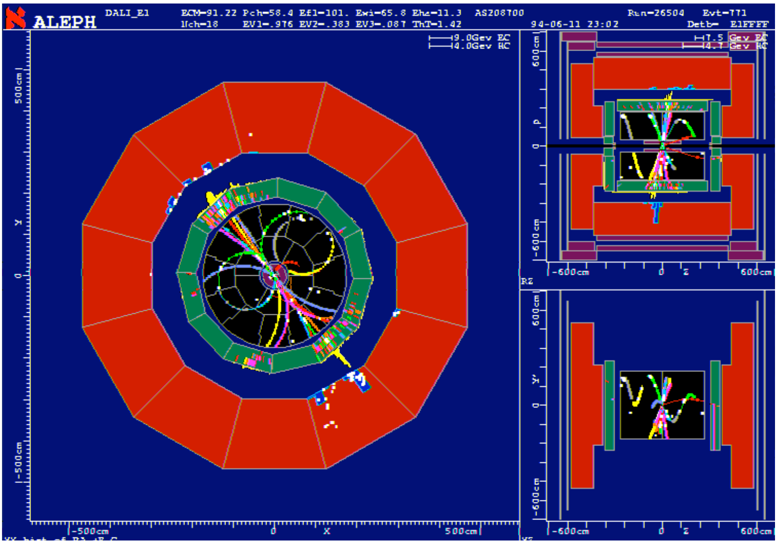
Figure 3. Amount of material (in units of radiation lengths) which a high energy particle, originating from the center of the coordinate system at a polar angle θ, traverses before it reaches the first active element of a specific detector system.

What are the pros and cons of the BaBar tracking detector (silicon plus drift chamber) ?

Any suggestions for improvements?

C Appendix: Example of problem to solve in class





D Appendix: Example of one exam problem

Take-Home exam
Experimental particle and nuclear physics
Question 6

The LHC-B detector

Answer the following in about 20 minutes (use Technical Proposal and Reoptimized TDR reports – please return after exam) :

- Justify the choice of spectrometer layout and detector components of LHC-B, in view of the physics goals of the experiment (see sect. 1,2 of the Technical Proposal)

- Explain why LHC-B has two RICH detectors, what is their purpose and give arguments for the choice of radiator and of location of these detectors in the overall LHC-B layout

- The initial design of LHC-B (as in Technical Proposal) had one fundamental flaw, which lead to a complete review and optimization of the detector (see Reoptimized TDR). Which one?

- Describe the Silicon Vertex Detector in LHC-B. In particular explain what are the main factors driving the decision on : support structures, orientation of strips , pitch size , temperature operation , location with respect to beam line. Finally, explain the behaviour with momentum of the space resolution on the impact parameter of tracks (i.e. the distance of closest approach to the interaction point) , as shown in fig. 7.15, page 46, of the Technical Proposal.

- The $B^0 \rightarrow \psi K^0$ is one of the important decays to be observed at LHC-B, to deepen our understanding of CP violation. ψ decays in either 2 muons or 2 electrons , while K^0 decays into 2 charged pions. So one looks for events containing either $\mu^+\mu^-\pi^+\pi^-$ or $e^+ e^- \pi^+\pi^-$. As you can see in fig.15.8, page 150, of the Technical Proposal, the resolution in the mass reconstructed from $\mu^+\mu^-$ or from $e^+ e^-$ is quite different. Try to motivate the difference, keeping in mind which detector components are relevant for the reconstruction of the two final states.

E Appendix: Description of assessment criteria

Grade 12 : fulfills the ILOs of the course.
For declarative knowledge ILOs, it means

- the student can explain very well the solutions to the problem assigned, and the solutions are all correct.
- The student shows clear understanding and overview of the subject when answering the questions after the presentation. Both general questions to probe all curriculum, and more specific questions on presentation, to see if the student can analyse problem from a new or different point of view, and has really understood what he has presented.
- no hesitations.

Grade 10 : fulfills the ILOs of the course with only minor flaws.
For declarative knowledge ILOs, it means

- the student can explain the solutions to the problem, and the solutions are all correct.
- when asked to analyse the problem from another point of view, hesitates and possibly cannot answer all question, but at least attempts to draw a reasonable answer.
- The student can answer general questions on the curriculum taught.
- Some hesitations

Grade 7 : fulfills the ILOs of the course, but with some flaws.
For declarative knowledge ILOs, it means

- the student is not able to answer all questions in the problem assigned, or not all correctly (maximum 20-30% is lacking). Clearly lacks an overview of the subject.
- when questioned on various parts of the curriculum, can answer some questions with confidence, and some others less confident.
- various hesitations.

Grade 4: fulfills the ILOs of the course with big flaws.
For declarative knowledge ILOs, it means

- the student is not able to answer all questions in the problem assigned, or can answer all but not all correctly (maximum 50% is lacking). Clearly lacks an overview of the subject
- when asked general questions on various parts of the curriculum, can answer only a few questions with confidence.
- many hesitations

Grade 2: barely fulfills the ILOs of the course.
For declarative knowledge ILOs, it means

- the student can answer some questions in the problem assigned correctly, but only a few.
- when asked general questions on the curriculum, answers with very little confidence, but some answers are correct.
- mostly hesitating.

F Appendix: Student evaluation

Answers can be : Series 1 = I agree , Series 2 = I don't know , Series 3 = I disagree

Lecture:

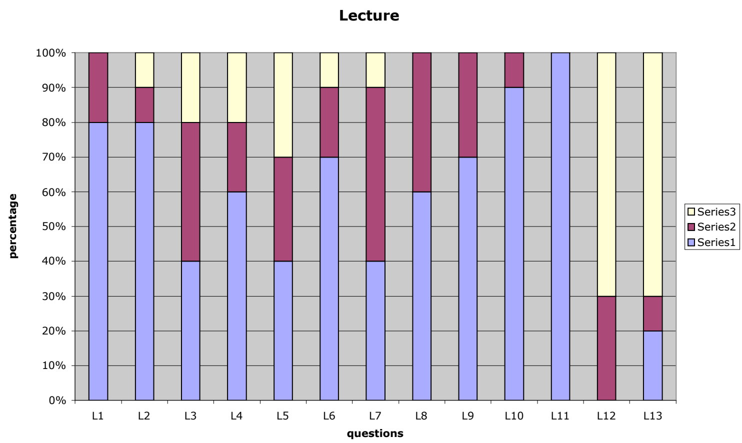
L1: The curriculum of this course is clearly presented in the lecture
L2: The slides support well what the teacher is explaining in the lecture.
L3: The format of the slides makes it easy to follow the lecture.
L4: In the slides, text and figures are well balanced so following the lecture is easy.
L5: I like slide presentation.
L6: I like blackboard presentation
L7: References to book or other material needed for preparation to the exam are clearly indicated in the slides.
L8: Goals of the lecture are clearly presented.
L9: Use of the pointer helps to focus on what is taught during the lecture
L10: The lecture helped me understand better the subjects I am supposed to learn for the exam.
L11: During the lecture, I have enough opportunity to ask questions
L12: During the lecture, I would like more breaks where we can discuss two and two
L13: The teacher speaks too fast

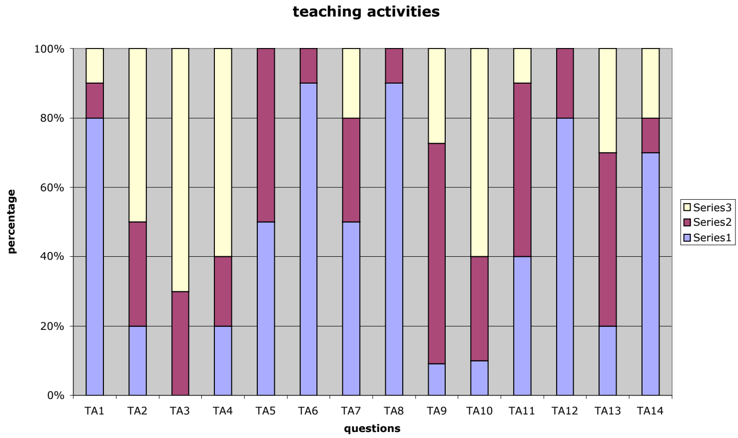
Teaching Activities:

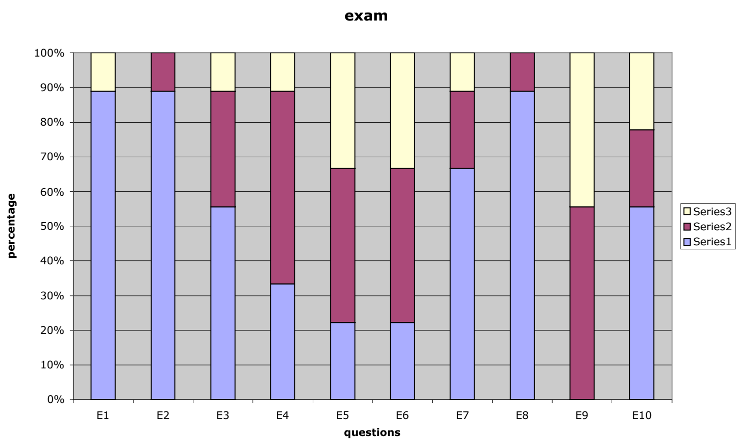
TA1: The exercises (calculations) help me learn better what is taught in the lecture
TA2: I would like more exercises during the lecture
TA3: I would like longer exercises during the lecture
TA4: I would like no exercises during the lecture
TA5: The exercises are clearly formulated.
TA6: The explanation of the exercise's solution is clear and helpfull.
TA7: I like when I am given the opportunity of explaining the solution to the exercise.
TA8: A problem (requires calculation but also some other knowledge gathered during the lecture or in lectures before e.g. BaBar or SuperKamiokande xample) helps me learn better what is taught in the lecture.
TA9: I would like more often problems in the lecture.
TA10: I would not like problems during the lecture.
TA11: The problems are clearly formulated.
TA12: The explanation of the problem's solution is clear.
TA13: It is difficult to solve a problem during the lecture, I need more time
TA14: I like to work in groups on a problem.

Exam:

E1: I use the recommended book to prepare
E2: I use the slides to prepare
E3: I use material online, beyond what suggested, to prepare
E4: I like the book suggested for the course
E5: I wish I was given more material to read, for preparing for the exam
E6: I know what I am expected to know for the exam
E7: I like a part of the last lecture devoted to explain more about the exam requirements
E8: I like the opportunity to come and ask questions to the teachers while I prepare
E9: Two days to prepare for one paper is not enough
E10: I would like to be given more exam-type problems during the course, to train




teaching activities
percentage
100%
80%
60%
40%
20%
0%
TA1 TA2 TA3 TA4 TA5 TA6 TA7 TA8 TA9 TA10 TA11 TA12 TA13 TA14
questions
Series3
Series2
Series1


exam
percentage
100%
90%
80%
70%
60%
50%
40%
30%
20%
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0%
E1 E2 E3 E4 E5 E6 E7 E8 E9 E10
questions
Series3
Series2
Series1

18

How can I teach to maximize the learning of "Roberts" (slow/nonambitious) and "Susans" (fast/ambitious)?

David Gloriam

Department of Medicinal Chemistry, FARMA, Copenhagen University

Introduction

The project deals with how to adapt the teaching to suit different students (slow/fast, ambitious/nonambitious. . .) i.e. those referred to by the adjunktpædagogikum course book as "Roberts" and "Susans" (Biggs and Tang; 2007).

The project involves planning of some of my teaching for the coming semester (fall 2009). I only have isolated parts of the courses and can thus not freely chose TLAs based on topics but rather have to improve on existing lecture and exercises. In this project I describe representative examples of a (1) lecture, (2) group exercise/workshop and (3) master project supervision in light of the problem formulation.

The lecture setting

The lecture that I have chosen to include in this project has the title "sequence alignments and phylogenetic analysis" and is held for a class of approximately 150 pharmacy students at their third year. I have had this lecture once, last fall, and it was part of my teaching supervised during adjunktpædagogikum. At that time I had taken over an existing set of lecture slides which were then to the greatest extent are made. The pedagogic considerations were discussed in the "reflection paper" upon my teaching, also written as part of adjunktpædagogikum . Now, I have revisited the presentation (Appendix A) by examining it through the eyes of Robert and Susan.

Slides 2 & 27

I added these two slides already last year and they do not need to be updated. I just want to note here that they explain the relevancy and use of two main subjects and that this is important, especially for "Roberts".

Slides 3-4

The lecture overview slide was too detailed. I have now updated it so that it does not included details of which the students have not yet heard. I believe an overview is good as it tells the students what is coming, however if being too detailed with new complex terms it might "scare" some students to think that is lecture will be very difficult and that they will not be able to understand it. I want to avoid expectations of failure.

Slide 7

This year I judged the "dot-plot" slide as not being of central importance and it was thus removed.

Slides 9-10 and slide 34

Pedagogic project in the "KNUD" course in natural sciences university pedagogics and didactics. The lecture contains two questions to be discussed in pairs. They have been chosen to cover the most important topics;

1) how to construct sequence alignments and
2) how to interpret a phylogenetic tree.

The question (1a-b) on slide 9 was good for the students to self process and work with the calculation of alignment scoring. However, I felt that another question should be added that can challenge Susans and also lead to higher-taxonomy considerations leading to a deeper understanding. For this reason I added question 2: "Why is it better to use the similarity than distance scores? " to the updated slide (no 10).

Slides 12-13

I wanted to make the point clearer on this slide and also integrate it better with previous ones. To do this I changed the title and color-coding the text that corresponds to the residue color-coding in the alignment. This is probably a clarifying change for everyone, not Roberts or Susans in particular.

Slides 22-25

Similarly, to previous comment these slides have just been clarified. The main message is to explain protein sequence profiles and this was better done by changing both slide titles and updating the text and illustration for the first slide.

Slides 28-32

The making of phylogentic trees is probably the most difficult part of the lecture and yet a very central theme. I made new slides for this section last fall and, although I wanted to make a special effort to improve them again, I could only think of small layout improvements increasing the clarity but no new pedagogical approaches.

Slides 37-38

I do not give ILOs at the beginning of the lecture as they would probably not be understood before the lecture, – this is what I reasoned for the lecture overview above (slides 3-4). This finishing slide is the closest to ILOs in this lecture. By grading the topics of the lecture I have designed it so that the student can him/herself 1) prioritize and focus home studies and also 2) choose a level of ambition. Another important addition is the references for Susans so that they can find more information. I believe that challenging Susans in a lecture and at the same time be understood by Roberts requires home work for the former type of student.

After the lecture

Students can download all lectures of this course from the course web site and my email address is available on the slides so that questions can be sent. I have tried to make it possible to understand the slides without my oral presentation, at least together with the book. After the lecture I invite for questions in whole class or individually at the desk. Giving room for individual questions is beneficial for meeting the different needs of Roberts and Susans.

Reflections from last year and tips for next year

Last year I enjoyed having this lecture and the response from the class was very good. I got answers for every question posed during the lecture, applauds when finished and one student walked up to me to ask questions afterwards. The fact that most students looked as if they were concentrated and listened well suggests that they also gained new knowledge, but it is difficult to assess to what extent I could reach them. Furthermore, several students may have understood less because I spoke English, but the class also contained ca 6 Icelandic students that prefer English to Danish. I have decided to take a Danish course for Scandinavians this fall. I also got a very good pedagogic tip from my external pedagogic supervisor, Per Geckler, that I will use this year. The advice was to ask the students to give me the Danish word for central, new English terms such as "sequence alignment" and "phylogeny". That would increase the understanding of these new concepts.

The group exercise/workshop setting

I have the main responsibility for one computer-based exercise and the pedagogical work on this is described in my reflection paper. However, for this project I work with a new group exercise, which I will only be co-managing. This is "Toolbox Exercise 2 – Conformational analysis and conformational energy penalty of binding". This is part of an elective course for Pharmacy Master students. There are usually ca 20 students on the course, most of which are relatively motivated. They have 2 hours to complete the exercise. The purpose of the exercise is to equip the students with skills in the "Schrodinger" software necessary to conduct their projects.

Introduction to exercise

For the group exercise described in my reflection paper I produced a 15 minute introduction summarizing the knowledge needed (the corresponding lecture had been 1-2 weeks ago and did not cover all topics of the exercise). I had planned to do the same thing for this new exercise. However, it is scheduled right after the corresponding lecture which has the same responsible teacher and provides full cover. What I believe can actually be improved would be to spend some time before the exercise to take questions from the lecture and also suggestively let the students in small groups define key words, such as “solvation” and “force field”. These terms are used repeatedly in the exercise.

Written instructions for exercise

For the group exercise described in my reflection paper I made multiple pedagogic improvements to the instructions. It is my experience that spending time on formulating clearer instructions pays off by increasing the understanding and decreasing the frustrations of students and at the same time saving time as students tend to get stuck less often. However, for this exercise also the instructions were very clear already from the beginning. It is structured in goal, background theory, methodology and then the actual exercise containing questions that I judge can adequately encourage high-level learning. However, I have made some improvements to the instructions that are found in appendix B. The track changes function has been used to document my updates. A short note is that it is nice to have some factual background about the molecule being worked on, Glutamate. I added parentheses to two words that I am not sure that the students would otherwise have understood the meaning of; conformational space (possible compound 3D structures) and complete (converged) search. To better explain the concept of electrostatic collapse I will add a picture of a collapsed molecule.

Giving help during the exercise

When answering students’ questions during labs I try to get a picture of how much the student has understood and to provide guidance at the right level and in simple words. One technique that I often use is to ask the student to self formulate an explanation for me as far as she/he can and then I fill in the parts where the understanding was limited. I strive to address all the students in a group to make sure that all of them participate and have understood. An observation I have made is that different students understand things in different ways and it is good if the support can be individualized. For example some students prefer to go through practical examples, whereas others like analogies or just a presentation of the background theory. I want the students to comprehend and do therefore not give answers for questions directly. Instead I share the information that the student needs to answer the question him/her self. When students have asked for help on a particular question I sit by until they have completed it. In this way I can be assured that they have understood and also avoid frustration resulting from getting stuck at a certain question.

After the exercise

Home studies are not possible as the software is very expensive, -it is essential that the students learn how to use the software during the scheduled exercises. I will suggest that the teachers goes through all questions in the exercise individually with each group when they are finished. This gives the opportunity to make sure that the students have understood and which parts are the most difficult. This is also a good time to ask what the students have learned, what was difficult and what can be improved. My experience from the other computer-based exercise is that students finish at different times and that the post-exercise talk is relatively successful in meeting different students at their level and also gaining information about how the exercise can be improved.

Master project supervision

Previous experience

Supervision of students is the type of teaching that I have the most experience of and it is also my favorite type of teaching. During the last year of my PhD I supervised three Master project students that all continued doing research in the group also after completing the project. Two of the students came so far that they influenced the development of their ongoing projects. All three chose to take on PhD studies, one in my group and two in other groups.

Explaining the project and aligning expectations

September 2009 to June 2010 (35 points) I will supervise my first master project student at the University of Copenhagen. The student chose me as he recognized me from classes and a computer-based project matched his skills, having worked with programming and web design. The first main concern of the student was that it is very difficult to get a good understanding of projects and how they will be to work with. Sending complex texts such as articles or project applications would probably just have scared him and I decided to book a meeting to explain the project and to let him ask questions. I also initiated a discussion about expectations on each other and about results. In short the discussion I emphasized that scientific results can never be ascertained on beforehand, I will not count clock-hours but want to see an honest attempt to carry out the project and that results are as depending on my effort as his i.e. without adequate help even the brightest student will have difficulties.

Supervision attitudes and techniques

Our first meeting (Dec 07) has been followed up with new meetings every 6th week to provide updates of my project, which is similar to the master project. The meetings have given the student some insight into how running a project works, the type of problems that may be encountered and how a computational chemist work together with organic chemists and pharmacologists. During a master project I make sure that students have understood what to do I often ask them to self explain the next steps. Furthermore, this time I want to test letting the student write a draft of the introduction and project plan of master thesis already when starting. This PBL element, if it works, could encourage independent thinking at an early stage and personal "ownership" of the project.

Special master project considerations for Roberts and Susans

Many of the considerations apply to all students. A master project should be well defined and separated into an independent (sub?)task, feasible within the given time-frame and contain elements of "learning-by-doing". The supervisor should provide help at a level appropriate for the student and stimulate the use of the students own innovation and creativity. However, a Susan could probably handle more freedom and faster-pace challenges. A Robert would need more frequent guidance and a larger effort in ascertaining that the tasks and the relevancy (project and skills) have been understood. I as the supervisor, need to accept that publishable results are not necessarily a goal of the student and that the ambition may often only be too get the desired grade.

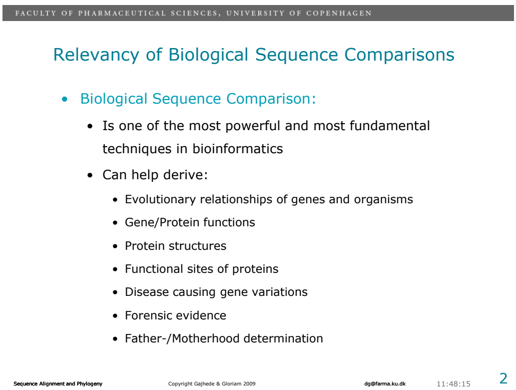
Ethical discussion about the prioritization of teaching resources

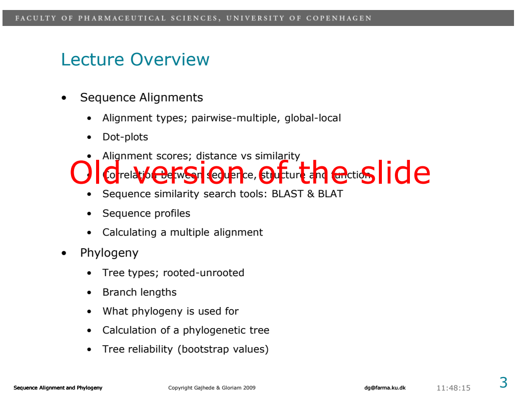
Ethical discussion was initially planned to be a primary part of the project, however the instructions have been clear on that the project must directly relate to specific courses and therefore this topic is only touched upon. I think that what can be concluded within the frames of this project and from adjunktpædagogikum is that by carefully designing TLAs much can be done to increase the learning outcome of Roberts and Susans without extra resources.

Should time and money be spent on the students which have the ability to learn the most, an "elite", or should the university focus on making sure that no one is left behind?

The adjunktspedagogikum course book has a reference on page 14 on this topic (Buckridge, Guest; "A conversation about pedagogical responses to increased diversity in university classrooms"). Due to the project instructions and time limitations I have not read it, but might do so later. My stand point (the only result here) is that for societal, humanistic and ethical reasons there is a need to reach as many as possible of the students. However, teachers should not forget to make the effort to provide the extra challenges needed for Susans. I think that "elite" classes, such as those currently introduced at the Danish Niels Brock high school (http://www.brock.dk/om-niels-brock/nyhederpresse/her-kommereliten.html) can increase the learning outcome of Susans. I suspect that many people fear that elite classes might foster personalities with a 'besserwisser' attitude that look down on others. This is a problem on the individual level, but not on the institutional, and I believe it also can to some extent be dealt with by providing the right teaching environment. As a contrasting perspective, this is not better than letting the "jantelov" make Susan-like students reduce their ambitions to not stand out from the crowd.

A Appendix: Slides from lecture on “sequence alignments and phylogenetic analysis” (excerpt)





Lecture Overview

- Sequence Alignments
  - Different types of sequence alignments
  - How to make a sequence alignment
  - Online alignment tools
  - Connection between sequence, structure and function
- Phylogeny
  - Types of phylogenetic trees
  - How to make a phylogenetic tree
  - What phylogeny is used for

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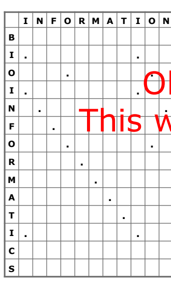
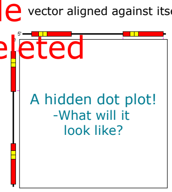
"Dot Plots" - Graphical Illustrations of Aligned Regions Within 2 Sequences



Old slide

This was deleted

- Dot plot of a retroviral vector aligned against itself



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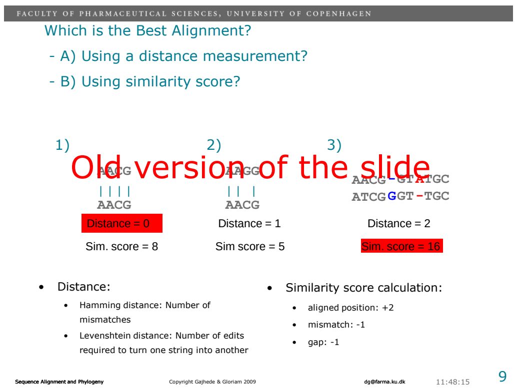
FACULTY OF PHARMACEUTICAL SCIENCES, UNIVERSITY OF COPENHAGEN
Which is the Best Alignment?
- A) Using a distance measurement?
- B) Using similarity score?
Old version of the slide
1)
AACG
| | | |
AACG
Distance = 0
Sim. score = 8
2)
AAGG
| | |
AACG
Distance = 1
Sim score = 5
3)
AACG-GTATGC
ATCGGGT-TGC
Distance = 2
Sim. score = 16
Distance:
Hamming distance: Number of mismatches
Levenshtein distance: Number of edits required to turn one string into another
Similarity score calculation:
aligned position: +2
mismatch: -1
gap: -1
Sequence Alignment and Phylogeny
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dg@farma.ku.dk
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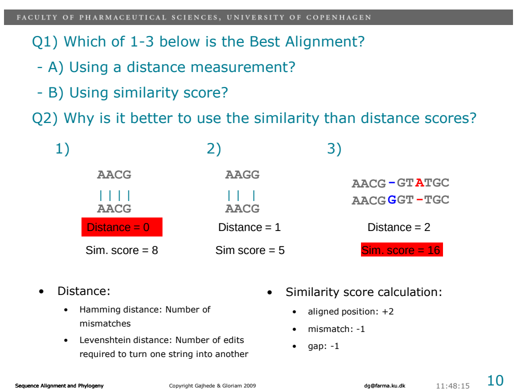
FACULTY OF PHARMACEUTICAL SCIENCES, UNIVERSITY OF COPENHAGEN
Q1) Which of 1-3 below is the Best Alignment?
- A) Using a distance measurement?
- B) Using similarity score?
Q2) Why is it better to use the similarity than distance scores?
1)
AACG
| | | |
AACG
Distance = 0
Sim. score = 8
2)
AAGG
| | |
AACG
Distance = 1
Sim score = 5
3)
AACG-GTATGC
AACGGGT-TGC
Distance = 2
Sim. score = 16
Distance:
Hamming distance: Number of mismatches
Levenshtein distance: Number of edits required to turn one string into another
Similarity score calculation:
aligned position: +2
mismatch: -1
gap: -1
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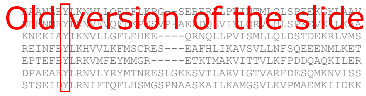
Multiple Alignment Advantages

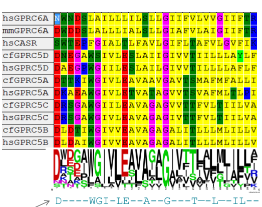
- Sequence alignment between multiple sequences can help to find functional sites (e.g., active sites) in a protein sequence
- Functional sites are conserved (un-mutated) in evolution



- Alignment profiles
  - Made based on multiple alignments
  - Can be use in sequence searches to increase sensitivity and selectivity (PSI-BLAST, Hidden Markov Models)

Alignment profiles

- Functionally important sites are evolutionary conserved (less mutated)
- A profile ranks highly conserved sites as more important
- Sequence searches using profiles have higher sensitivity and selectivity (PSI-BLAST, Hidden Markov Models)



Most important sites

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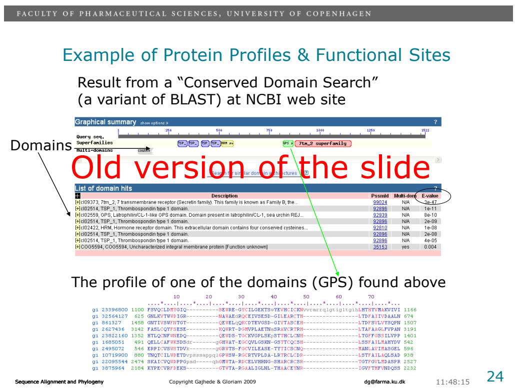
FACULTY OF PHARMACEUTICAL SCIENCES, UNIVERSITY OF COPENHAGEN
Example of Protein Profiles & Functional Sites
Result from a “Conserved Domain Search”
(a variant of BLAST) at NCBI web site
Domains
Graphical summary
List of domain hits
Old version of the slide
The profile of one of the domains (GPS) found above
Sequence Alignment and Phylogeny
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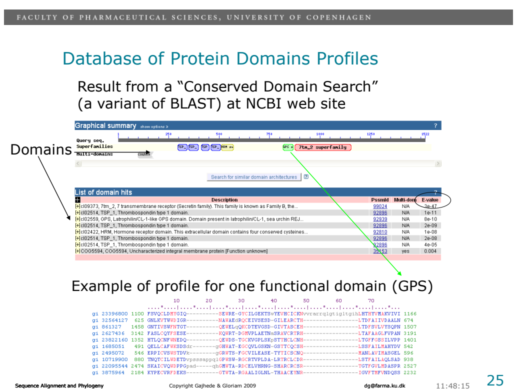
24


FACULTY OF PHARMACEUTICAL SCIENCES, UNIVERSITY OF COPENHAGEN
Database of Protein Domains Profiles
Result from a “Conserved Domain Search”
(a variant of BLAST) at NCBI web site
Domains
Graphical summary
List of domain hits
Example of profile for one functional domain (GPS)
Sequence Alignment and Phylogeny
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11/30/2009

What is Phylogeny Used For?

Species Comparisons:

- Evolutionary analyses e.g. protein family evolution
- Selection of appropriate (genetically similar) model organisms

Protein Family Comparisons:

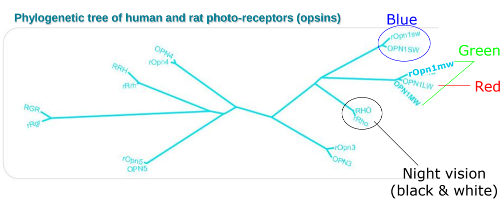
Based on protein relatedness it is possible to predict:

- Physiological functions of proteins with unknown functions
- Pharmaceutical data such as ligands

Question

- Which difference is there in the color vision of humans and rats?

Phylogenetic tree of human and rat photo-receptors (opsins)



Summary

Old version of the slide

- Sequence Alignments
  - Alignment types; pairwise-multiple, global-local
  - Dot-plots
  - Alignment scores; distance vs similarity
  - Correlation between sequence, structure & function
  - Sequence similarity search tools: BLAST & BLAT
  - Sequence profiles
  - Calculating a multiple alignment
- Phylogeny
  - Tree types; rooted-unrooted
  - Branch-lengths
  - What Phylogeny is used for
  - Calculation of a phylogenetic tree
  - Tree reliability (bootstrap values)

Basic knowledge
Very useful
Advanced

Summary

- Sequence Alignments
  - Alignment types; pairwise-multiple, global-local
  - Alignment scores; distance vs similarity
  - Correlation between sequence, structure & function
  - Sequence similarity search tools: BLAST & BLAT
  - Sequence profiles
  - Calculating a multiple alignment
- Phylogeny
  - Tree types; rooted-unrooted
  - The meaning of Branch-lengths
  - What Phylogeny is used for
  - Calculation of a phylogenetic tree
  - Tree reliability (bootstrap values)

Basic knowledge
Very useful
Advanced

- If you want to know more consult the course book. Wikipedia also has good entries on sequence alignments and phylogeny.

B Appendix: Changes to written instructions for excercise (excerpt)

Toolbox Exercise 2 – Conformational analysis and conformational energy penalty of binding

Goal

~~The aim of this exercise is to demonstrate:~~ After this exercise you should have learned how to:

Comment [d1]: After AdjPed no teacher can miss that the important thing is not what the teacher does, but what the student learns.

- ~~How to~~ perform a conformational search on small molecules.
- ~~How to~~ identify and handle electrostatic collapse.
- ~~How to~~ calculate conformational energy penalties of binding.

Calculation of conformational energy penalties of binding

When a ligand binds to a protein it usually has to change conformation from the most stable one in solution to a conformation that fits the active site. This change in conformation may cost energy, which subtracts from the free energy of binding and decrease the binding affinity. We call it the conformational energy penalty of binding (Epenalty) and it is the difference in conformational energy between the most stable conformation in water and the binding conformation. If Epenalty is significantly higher than 3 kcal/mol **for high affinity ligands** it is considered an unlikely binding conformation.

~~The procedure~~ Epenalty is calculated as follows:

1. Calculate Eglobal:

Comment [d2]: I just think the numbers 1-5 are categorized under the Energy term they are part of calculating.

   ~~1~~a. Perform a conformational search of your compound in water to identify the global energy minimum conformation.

Formatted

   ~~2~~b. Calculate the energy of the conformation from step 1 in vacuum. This is ~~to get~~ Eglobal.

2. Calculate Ebinding

   ~~3~~a. Perform a constrained energy minimization of the binding conformation in water constraining each atom to only be allowed to move ~~only~~ 0.5 Å before a force constant of 500 kcal/mol is applied.

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   ~~4~~b. Calculate the energy of the conformation from step 3 in vacuum. This is ~~to get~~ Ebind

3. Calculate Epenalty

   ~~5~~a. Subtract the energy of the global energy minimum conformation from the energy of the binding conformation (Epenalty = Ebind – Eglobal).

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Electrostatic collapse and how to avoid it

Comment [d3]: It would be nice to add a picture of an electrostatically collapsed molecule.

Due to inadequacies in the force fields and the solvation models flexible compounds with the possibility of forming intramolecular hydrogen bonds may suffer from electrostatic collapse. This means that the molecule structure collapses i.e. is distorted because two electrostatic groups in the molecule interact, whereas they would~~, which are~~ in reality be shielded by water molecules~~, interact and result in distorted structures and~~ Electrostatic collapse results in an overestimation of the conformational energy.

The only way to avoid ~~the problems arising from this internal electrostatic interaction~~ electrostatic collapse is to turn off internal electrostatic interactions during the conformational search and the constrained minimization. Then afterwards calculate the energy of those conformations in vacuum with the electrostatics turned back on.

The procedure for changing the calculation setup to avoid electrostatic collapse is as follows:

1. Setup the job as ~~you would~~ normally ~~do~~ (see next page) but instead of running the job by clicking Start you should click Write.
2. Give the job a jobname that you can recognize again.
3. Use a text editor (bottom panel next to the Firefox icon) to open the file jobname.com.
4. Insert a line just before the READ keyword (MacroModel Reference Manual 4.5):
5. CHYD 1 0 0 0 0.0000 0.0000 0.0000 0.0000
6. Save and close the file.
7. Go to Applications -> MacroModel -> Start Job From File, select the job and click start (remember to keep the input structure in the work space). The output is automatically incorporated into your project.

The Schrödinger modules

In this exercise you will use three applications in the Schrödinger Suite: a conformational search application and the energy calculation applications from the previous exercise. Many of the parameter settings relevant in this exercise are the same as described in toolbox exercise 1.

19

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

Nanna Bjarnholt

Department of Plant Biology and Biotechnology, LIFE, University of Copenhagen

Introduction

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

Project background and aim

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

Course and subject outline

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

Motivation

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

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

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

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

Teaching/learning activities

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

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

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

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

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

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

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

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

New teaching plan

Structure

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

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

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

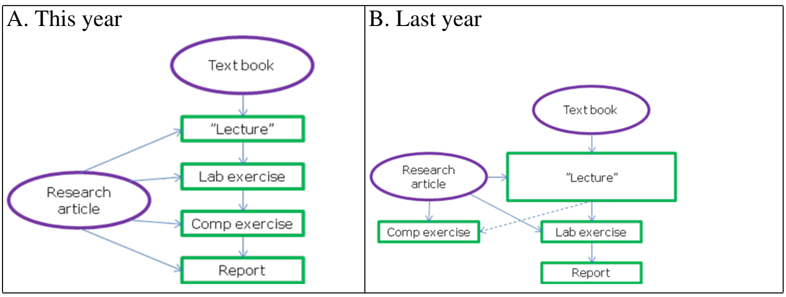

Fig. 19.2. Schematic of this year's and last year's teaching plans. Comp exercise = computer exercise. "Lecture" refers to the auditorium based teaching.

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

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

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

Interactive elements in "lecture" session

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

- Understand how metabolite profiling can be used in plant genomics

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Skills

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

Competences

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

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

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

20

Generation of appropriate learning activities for a student-activating learning

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Introduction

Knowledge is constructed through learner activity and interaction. Activity has two main roles. The fact of being generally active provides general alertness and efficiency. Activity specifically keyed to the intended learning outcomes (ILOs), using different sensory modes of learning to provide multiple access to what has been learned, is a very powerful way of learning.

Much of what is considered good practice in higher education is based on the assumption that active learning is more effective than passive learning and that interaction between the teacher and the student, among students, and between students and course material is a critical part of active learning (Mehlenbacher et al.; 2000). Being active while learning is better than being inactive. Activity heightens physiological arousal in the brain, which makes performance more efficient (Biggs and Tang; 2007).

Wittrock (1997) describes a study, where students were required to learn from text in increasingly active ways: reading silently, underlining important words, writing out the key sentences containing those words, rewriting sentences in one's own words, to the most active, teaching somebody else the material. There was a strong correlation between extent of activity and efficiency of learning (Wittrock; 1997). Similarly Felder (1993, 1995) has emphasized the integration of active and collaborative learning into engineering education for more than a decade and has reported dramatic results in terms of student responsiveness, satisfaction, and problem-solving flexibility with curriculum content.

Interactive teaching is a highly effective mode of activating students (Biggs and Tang; 2007). Becker and Michael (2001) have observed, from their extensive longitudinal survey on teaching methods in undergraduate economics courses, that the preferred method of lecturing among students is “chalk and talk”. In the conventional 45-min. lecture, students lose concentration generally after approximately 20 min., and learning is no longer optimal (Newble and Cannon; 1998; Brown and Manogue; 2001). This process can be countered by adding activating elements into the lecture.

Problem-based learning (PBL) is an example of a very efficient approach towards student activation (Biggs and Tang; 2007). In PBL, the starting point for learning should be a problem, query or a puzzle that the learner wishes to solve. PBL is a student-centered instructional strategy, in which students collaboratively solve problems and reflect on their experiences. It was pioneered and used extensively at McMaster University, Hamilton, Ontario, Canada (from Wikipedia). Characteristics of PBL are: learning is driven by challenging, open-ended problems; students work in small collaborative groups; teachers take on the role as “facilitators” of learning. Accordingly, students are encouraged to take responsibility for their group and organize and direct the learning process with support from a tutor or instructor. Advocates of PBL claim it can be used to enhance content knowledge and foster the development of communication, problem-solving, and self-directed learning skill.

Students learn through activating different sense modalities: hearing, touch, sight, speech, smell and taste. The more one modality reinforces another, the more effective the learning (Biggs and Tang; 2007). Lecture theatres offer less scope for activity than for example wilderness areas, but it is possible to keep students relevantly active in the classroom. It is a good idea to break up long periods of lecturing with different activities such as multiple-choice questions, short-answer questions, essay questions, short writing assignments, classroom simulations or experiments, etc. Better still is when the activity addresses specific intended learning outcomes. Providing learning activities relevant to engage the students with the ILOs is thus of great importance.

Objectives

According to many authors cited in the Introduction, learning becomes more effective if the participants are active. In order to achieve improved learning, there have been developed such methods as for example PBL and case studies. They are effective but I do not see them as always applicable. Simpler ways to improve the learning process of university students were therefore of great interest to me. I have introduced different activating elements into my lectures in order to test and evaluate the concept of interactive teaching and examine the usefulness and acceptance of different activating elements among the students. This study was carried out by lectures, which I held at the courses "Molecular Plant Biochemistry and Physiology" and "Bioinformatics 2".

Methods

03-12-08 I gave 2 lectures (1.5 h in total) at the course Molecular Plant Biochemistry and Physiology (240028). There were 9 students during my lessons, while there should be 12 students on the course. It is an elective course offered at the Department of Plant Biology and Biotechnology, Faculty of Life Sciences. The course is offered for the 1st year master students of the Biology-Biotech program.

06-01-09 I gave 2 lectures and 3 practical exercises (3 h in total) at the course Bioinformatics 2 (240006). There were 10 students during my lessons, while there should be 14 students on the course. It is an elective course offered for "students at the master level working in areas of biology who are interested in applying bioinformatics in combination with other biological sciences as well as students interested in being familiar with the basic concepts and principle applied in bioinformatics".

My lessons consisted of an introduction and then presented a real-life case that has already been carried out by me during my research. Since the methods and techniques used to solve the case were very new and complicated and the students were not familiar with them, I gave up with designing a PBL-based lesson.

I have prepared a number of TLAs (teaching/learning activities) related to the content being discussed during the lectures. Most TLAs were developed in such a way that they suited the ILOs, which were quite specific to the particular professional area. I have mostly used a simple form for student activation, which is to ask questions to the students during lecture, they had the opportunity to respond. Lectures were interrupted several times, and students were encouraged to take a position on and then answer the questions. The questions were both convergent and divergent (Biggs and Tang;

2007, p. 121). In the case of the convergent questions, “why”-questions was asked afterwards to hear the arguments for the answer. Once I used a graph to the question, where students were asked to interpret the graph in relation to the topic that was reviewed. Most of the questions were individual (asking questions and expecting individual students to answer them), but some were based on a group work (with 2-3 students in group) for 2-5 min. One question was asked in such a way that the students had to answer it with a YES/NO answer by raising hands.

I have used videos and whiteboard in several occasions. One TLA was problem-based: I gave one difficult question (problem) somewhere in the beginning of the 1st lecture, and then I gave the necessary background for this problem to be solved. I came back to the problem at the end of the 2nd lecture. Students had to work in 4 groups assigned by me (2-3 students per group) to solve it. To help the students solve the problem, I pointed at one slide during the presentation, telling them that this information would help them to solve the problem, reminding them the problem in question.

One of the two computer exercises solved by the students in groups during the Bioinformatics 2 course was used for the exam.

To get a quick indication of how the lessons went (students’ learning and my teaching) and which points should get more attention next time, I gave a questionnaire to the students with two questions (see all the answers in Appendices A and B):

- What were the most important points of this lecture?
- Did you have any particular difficulties during this lecture?

If some quite minor aspect would be seen as “the main point”, this would be an indication that either I or students have a problem. The second question was asked to point out what should be discussed better the next time.

Results and discussion

Constructive alignment

Molecular Plant Biochemistry and Physiology course.

The constructive alignment between the course content, assessment and ILOs was pretty good. Moreover, there was a very good alignment between the course and the study program (MSc Programme in Biology – Biotechnology) ILOs. The course description and the study program description were written in exactly the same format.

ILOs of my lectures at this course were made in agreement with the ILOs of the course:

The aim of the lecture is to give the student a basic knowledge of metabolomics, an important research topic within modern science. The lecture will illustrate how novel technologies within metabolomics are used to produce coherent knowledge of complex biological systems. The use of the new knowledge in designing crop plants for the future using genetic engineering will be discussed.

After completion of the course the student should be able to:

- describe principles, applications and experimental setup in metabolomics
- identify specific problems within plant biology, which could be solved by metabolomics
- read scientific articles about application of metabolomics, interpret the results presented and take a critical and creative standpoint to the presented scientific problems.
- transfer theories and principles from metabolomics to solve new questions posed by the research community, industry and the society.

The Bioinformatics 2 course.

The course description was not as extensive and organized as for the Molecular Plant Biochemistry and Physiology course. This was thus not so easy to characterize the constructive alignment between the content, assessment and ILOs of the Bioinformatics 2 course. The ILOs of my lectures were the following:

The aim of this lecture is to give a student a deep insight into metabolomics with focus on untargeted metabolic profiling, following the introductory lecture about basics of metabolomics.

The lecture & exercises will demonstrate how plant-insect interactions can be elucidated by untargeted metabolic profiling. The use of the new knowledge in designing crop plants for the future will be discussed. The exercises deal with the procession of LC-MS data from plants & statistical analysis of the metabolite data.

After completion of the lecture the student should be able to:

- describe experimental setup in metabolomics
- identify specific problems within research, which could be solved by metabolomics
- use metabolomics as an integrated part of a research project
- read scientific articles about application of metabolomics, interpret the results presented & take a critical & creative standpoint to the presented scientific problems
- transfer theories & principles from metabolomics to solve new questions posed by the research community, industry & the society

Reflection on teaching and TLAs chosen

Molecular Plant Biochemistry and Physiology course

I met active and engaged students. They were willing to answer my questions and interrupting me sometimes with comments or asking unplanned questions. The questions asked by the students indicated that they could understand what I was talking about and that they were thinking in a global perspective about the applications of the knowledge obtained (evaluation category of the Blooms taxonomy). The course was based on the interactive teaching from the beginning; it was clear that the students were used to such a teaching. Thus, no effort was required from my side to make them active – I just had to keep their "active spirit" and enjoy them showing a lot of interest in the subject.

I did not experience silence and empty faces when asking questions. I could not see any "Roberts" in the class (Biggs and Tang; 2007). There were in general at least a couple of students wishing to answer individual questions. I tried to say "Good" or "Very good" every time to the student who answered the question and repeat the answer to the whole class.

The questionnaire answers by the students (Appendix A) indicated that the students were pretty good in finding the major points of the lecture. Some students have experienced particular difficulties with some points, which I would have to address better next time.

There was an abundance of individual questions in comparison with other activities during the lecture (which were the easiest TLAs to design), but the lecture worked fine. This made me think the plan with a lot of individual questions and not so many other kinds of TLAs was good enough to be repeated during the next course (Bioinformatics 2).

The Bioinformatics 2 course

I had an afternoon session with students that had a conventional (not interactive) morning lecture. The teacher from the morning session told me he did not have enough time for the material he was gonna give, so he went through everything very fast. I probably got tired students, which really needed some activation. But I did not adapt to the situation. I did not have a "plan B", so I went through my plan with abundant individual questions anyway. Only the first two individual questions were answered, the second one was answered incorrectly. This was the last time I have heard an answer, my next questions were not answered. I gave the students some time to think on the answers, but afterwards was starting to explain the answers by myself. In some cases I could see students showing their agreement with the explanation – as if this was what they thought by themselves. I am not sure this would help with providing the students more hints that could lead them to the answer, since the students seemed to not wanting talk, maybe being afraid of giving a wrong answer.

The situation required on-the-spot improvisation in response to the events occurred. For example, after not getting any answer to one of the individual questions, I could have asked the students to discuss it in groups for some time and then come with a "group answer". A very good response to a question when the students had to raise their hands to give a YES/NO answer was another indication that the students were at least sometimes too shy to give an individual answer. The fact that the majority of the students have generally pointed correctly at the major points of the lesson indicated that most of them could understand what I was talking about.

The lectures were mixed with 3 computer exercises (in the same computer room). We have experienced huge computer problems for the first of the practical computer exercises (not enough memory); that was not good for the general mood either. The fact that I have tested how the program works on one of the student computers in my building did apparently not help to prevent the problem – the student computers in the classroom had less memory.

Finally, my expectations to meet students that did not require too much activation (because my first students from the previous course were like that) and not being ready for a different scenario was a mistake.

Conclusions

The results of this small study were not surprising – they show that students learn best when they are actively involved in lectures. Students intensified their attention when active elements were present – it sharpened their focus on the lecture. This assumption is supported by the fact that students remembered much better the elements of the lecture included in different TLAs than in general explanation of the subject. This could be for instance seen in the answers to the "major points"-question of the questionnaire. Three students of the Bioinformatics 2 course, which did not seem to understand the main points of the lesson, mentioned some elements included in the TLAs as major points.

This small study shows that not all the activities are suitable for all types of students. Thus, the TLAs should be designed considering student groups with different responses and levels of activity. Student behaviour should be a basis for rethinking and re-planning a lesson. Good teachers should be sensitive to students in face-to-face instructional settings and frequently adjust the in-class presentation of course material in response to student questions, body language, and classroom mood. Good teachers should learn how to revise their delivery of class materials to capitalize on student interest and motivation, tailoring their lesson to the situation and learning opportunity at hand. For example ask the students to discuss the question in groups and then give a "group answer", if the students do not answer an individual question. Individual questions is a good activity if the students are active and not shy. Otherwise more questions where students have to vote or raise their hands in order to choose the right answer are more appropriate. The voting could be made twice: after the first time the students get a chance to talk to each other about the answer they chose and then they vote again.

Many good examples of TLAs for interactive teaching are described by Fuller (1998) and in (Biggs and Tang; 2007, chapters 7 and 8, pp. 105–162). But most of them are suitable for a long-term teaching (not just one lesson as it was in my case). It is probably a good idea for a one-lesson teaching to start the lesson with some multiple-choice questions to understand "the level" of students (how much they know), and use the test as a basis for how the material should be delivered and which points require special attention.

A Appendix: Students’ evaluation of Molecular Plant Biochemistry and Physiology”.

STUDENTS’ EVALUATION. Course “Molecular Plant Biochemistry and Physiology”.

What were the most important points of this lecture?	**Did you have any particular difficulties during this lecture?**
Metabolic studies is a new area, but important! Can be used for different purposes, a lot like genetics I think.	Yes, a lot of new/difficult stuff (I am not studying biotechnology!). Especially the genetic/metabolic techniques are difficult, but I understood quite a lot and got the big picture I think.
- Techniques of metabolite profiling with different types – LC-MS, GC-MS, etc. - The way of analyzing the fragmentation to see the metabolite. - The softwares & which gives the quantification & the statistical analysis part to see the level of significance.	NO!
To get knowledge what is the metabolic profiling and how we use it in different types of investigations. What kind of data can we obtain and how to analyze it to get the information we are looking for.	No. All important informations were explained quite well.
That metabolomics can be used to identify relevant metabolites, in order to reveal certain plant properties. Especially it is a strong tool when used together with statistics and classical genomics.	I am not sure I understand the C part of the metabolic (LC-MS) profiles. But overall, the lecture was good and understandable.
- How metabolite analyses can be used in identifying e.g. resistance compounds in plants. - Which methods are applied for metabolomics analyses – LC-MS & GC-MS etc. for extraction and detection – and computer software for analysis of the different compounds.	- The genetics part (F2 question) was a bit difficult – far away, but it was very well explained. - Example 2 was not as understandable as example 1.
- Distinction of metabolomics from genomics and proteomics - The applications of metabolomics	- The genetics part (F1 vs F2) was a bit tricky, but you gave a good explanation. - Difference between GC, LC and CE.
- Good examples on what kind of results such analysis can give – Why make it? - The whole project: from starting material (F2) to the analysis methods to data analysis. - Nice overview.	The Principal Component Analysis
Good relevant examples which explain why metabolomics is a relevant and good tool to access new information about plants in relation to many factors which the plant is exposed to such as stress both abiotic and biotic.	I had difficulties with the PCA even through I have heard it before I have never understood it good enough but your explanation on how the PC1 and 2 is defined helped a bit.
- Than metabolomics will show a snapshot of the state of the organism, and that this metabolic state is continuously changing due to environment inside and outside the plant. - The applications of metabolomics.	The whole of example 2.

B Appendix: Students' evaluation of Bioinformatics 2.

STUDENTS' EVALUATION. Course "Bioinformatics 2".

What were the most important points of this lecture?	**What were the most important points of this lecture?**	**Are you considering using metabolomics/metabolic profiling in your (future) projects?**
Understanding of metabolomics and untargeted metabolic profiling. Learn how to use MetAlign program.	Computer problems, the 1st exercise.	Only if it is relevant for my projects, but it will not be focusing on metabolomics.
The difference between metabolomics and the more normal "-omics". Overview of experimental setup in this project. Point about F2 generation.	Computer problems. The F2 generation point was a bit tricky. Interpretation of MetAlign data.	Yes
Correlation. PCA. Clustering method. How to choose a group of metabolites to further looking up which correlate most with some phenotype feature	I like this lecture, I understand now basics of metabolite profiling. Negative was that exercise 1 didn't run – but it's not a teacher fault.	I have met 1st time this topic, but I found it very interesting and very informative. Yes, I am considering using these techniques in my future projects.
How you can obtain, detect, and analyze metabolites. It is a good idea to have mixed genotypes, e.g., in the correlation analysis. You can use correlation analysis and PCA to analyze the metabolics data and give a suggestion on which metabolites correlate with which biological condition.	No. Except that MetAlign didn't work.	No
The use of MS and MetAlign software.	Problems with the programme. Took too much time to get the results and the computer didn't have enough free space.	No…
How to use metabolic profiling in respect to problems in the true world.	The program doesn't seem to work properly on these computers.	Don't know what the future brings ;-)
Flow-chart: from problem to identification. Basic concepts of metabolomics including Eigenvector. Get a feeling of the software MetAlign.	No. Computer problems for the exercise.	Not at the moment. But it could be relevant later on and it is definitely interesting.
That you relatively easy can make an analysis of a metabolic profile! Nice!	Yes, never run locally on an old PC! But otherwise everything was very well described.	Maybe. If the right project comes along.
How to analyze results and how to use MetAlign. Last but not least the importance of using F2 plants when you want to analyze metabolites.	Nej, det var godt nok.	Niks, but it is very exiting.
The importance of using F2 plants. The technical details of MetAalign. The principles of a real metabolomics study. After 8 ☺	No	It could be nice to learn and use it in the future.

21

Communication between students and teacher

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Introduction

University education is usually taken like the one way teaching when teacher is delivering the information and student is the recipient trying to get as much as possible from the educational process. At least, this is the old point of view, however, still persisting in some subjects and lectures. Modern way of university education is on more advanced level activating the students and encouraging the application of their skills in learning process. With less information, more effect and knowledge. Despite the enormous development in the university pedagogic, there is still only minor experiences and practical advices, and insufficient knowledge and sources for learning large classes and delivering the pure fact science to the students. Primary, this project was aimed on investigation of reasons causing the low effect of well-prepared practical course on learning outcome. However, the results were surprising enough (see experiment 1) to evoke the new investigation focused on the communication between teacher and students, not only in the small groups but also in the large groups during theoretical lectures (see experiment 2). The basic communication between student and teacher is not personal. The educational process involved the teacher delivering and presenting the information (science) on one side, and students elaborating and applying the information on the other. Independent on the how simple and easy straight going this educational line may seem, there are many problems, key points, curves and breaks which have to be considered in order to get the complete view on communication aspect between teacher and students.

Within the many aspects, one appear to be crucial and probably more important than the others; belief of student in teacher and in skills to apply the knowledge, and vice versa: self-efficacy. Perceived self-efficacy refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments. Peoples belief in their efficacy have diverse effects. Such beliefs influence the courses of action people choose to pursue, how much effort they put forth in given endeavors, how long they will persevere in the face of obstacles and failures, how much stress and depression they experience in coping with taxing environmental demands, and the level of accomplishments. Efficacious people are quick to take advantage of opportunity structures and figure out ways to circumvent institutional constraints or change them by collective action. Conversely, inefficacious people are less apt to exploit the enabling opportunities provided by the social system and are easily discouraged by institutional impediments. Seen in the perspective of good teacher-student relation during the educational process, efficacious teachers believing in themselves and their skills to teach the science on one site, and efficacious students believing in the teacher's and their own skills on the other, are the best examples of successful communication during university study. We cant separate students from teachers and teachers from students. Both groups individually develop different patterns of competencies and deploy them selectively depending on the match of efficacy beliefs to environmental demands and on anticipated outcomes. Student are thus environment for teachers and teachers develop dependent on the students reactions and feedback.

Highly compatible communication between students and teachers represents the outcome of two incomes: i) efficacy beliefs and ii) outcome expectancies. The combination of these two factors may have particular effect and investigation of both aspects by teachers and students has a big potential for improvement of university education independent on, if the educational mechanisms are applied in small or large groups of students.

Results

Experiment #1

During my practical 2-days-course within the cell biology for the first year student of Veterinary Medicine, the student learn the basic molecular method of PCR. First, the students have theoretical lecture with professors

		Outcome expectancies	
		-	+
Efficacy beliefs	+	Protest grievance social activism milieu change	Productive engagement aspiration personal satisfaction
	-	Resignation apathy	Self-devaluation despondency

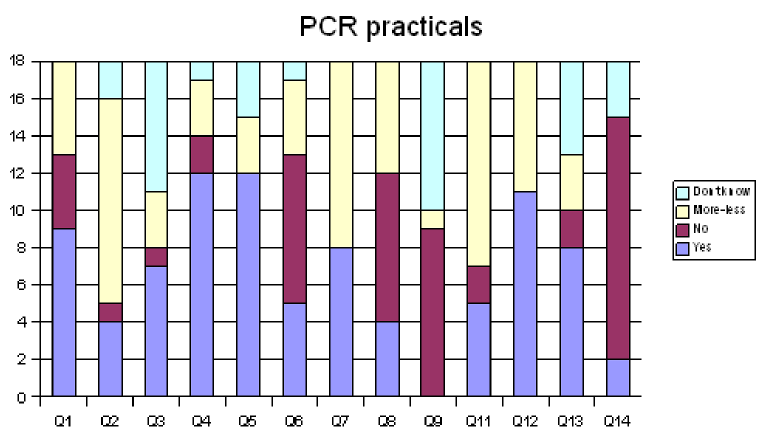
Fig. 21.1. The effect of different patterns of efficacy beliefs and performance outcome expectancies on behavior and affective states. The pluses and minuses represent positive and negative qualities of efficacy beliefs and outcome expectancies.

where they go through the basic principles of the method as well as the basic structure of evaluated molecules. The lectures are very well prepared and performed. However, I have often the feeling, that the majority of the students did not comprehend the topic. So I go from student to student and individually explain the topic if they step into the problems. Anyway, not all of the students ask. Students were given simple questionnaire which was focused on evaluating the course and tools used in it as such, as well as, analysis of students personal impressions and experiences during course, followed by personal interview clarifying the uncertainness and discussing the possible relevant aspects:

1. Did you have laboratory experience before this exercise (handling pipets, knowing items names, etc.)?
2. In your opinion, did the lecture before the practical exercise give you sufficient preparation into PCR topic? (you knew, what's happening in the reactions)
3. Did you like to work with the booklet you had for the exercise?
4. Were the protocols easy to follow?
5. Were the questions in the book helping by understanding the PCR more in the depth?
6. Did you sometimes get "lost" in the book?
7. Did the teachers explain the topic so you could understand what is happening?
8. Did you ask every time you didn't understand something?

9. Would you prefer some other form of learning about PCR?
10. Which?
11. Can you say what PCR is now straight away?
12. Did you have a feeling that you understood what the PCR is about after the exercise?
13. Would you like to have more courses like this during your study?
14. Are you disappointed with something after your first (second) year at the University?
15. With what?

The results of experiment #1 showed general satisfaction of students with teaching, teaching tools as well as the outcome of the course. However, questions Q6, Q7 and Q8 aimed on communication between teacher and students gave partially negative answers. About 50% of students got lost in the protocols, however, they did not ask if they were confused or did not understand something. Students also got impression, that the course responsible (lab technician) could only more or less explain the topics and they would prefer to have more detailed introduction during the lecture.This result was moreover confirmed by personal interviewing of the random groups of students (notices can be delivered after requirements).



The logical conclusion from the first experiment was to perform further investigation aimed on communication between students and teachers. This aspect is, in my opinion, the most important especially for the first year student struggling with different educational system and handling the information. Moreover, communication has a long-term impact on development of students (successful study and work applications) and teachers (improving teaching skills and personal attitude). From communication point of view, self-efficacy (could be also understood as a trust in each other to become better) seems to be a great tool for analysis of communication between students and teachers (Experiment #2). The detailed analysis could so help to improve the students-teachers interactions and significantly influence the educational process from student's and teacher's points of view.

Experiment #2

Experiment #2 was performed in the same group of students who were evaluated also during my lectures in big classes. Teachers included in the study were from IBHV, LIFE, KU. Teachers were given the STEB1 test for self-efficacy (modified from (Enochs and Riggs; 1990)) and students answered the modified STEB1 test aimed on their beliefs in teachers influence and beliefs in their own skills to learn (see Appendix A). Test contains reverse-polarity questions and is build from 2 focus area questions:

1. outcome: how far is the teacher able to modulate students learning
2. beliefs: how are the teacher's and/or student's beliefs in themselves to posses and apply the skills for successful learning

The higher total score, the better can teacher combine outcome and beliefs (better teacher). The higher score by students represents the better skills to accept the teachers input and the better use of personal resources to learn the science.

	Total (max 115)	**Outcome** (max 50)		**Beliefs** (max 65)	
	Average	**Average**	*StDev*	**Average**	*StDev*
Students (n=17)	80,29 *(± 5,06)*	**34,88**	*4,08*	**45,41**	*4,62*
Teachers (n=7)	87,86 *(± 5,81)*	**33,86**	*2,97*	**54**	*4,4*

Fig. 21.2. Outcome and beliefs of students and teachers

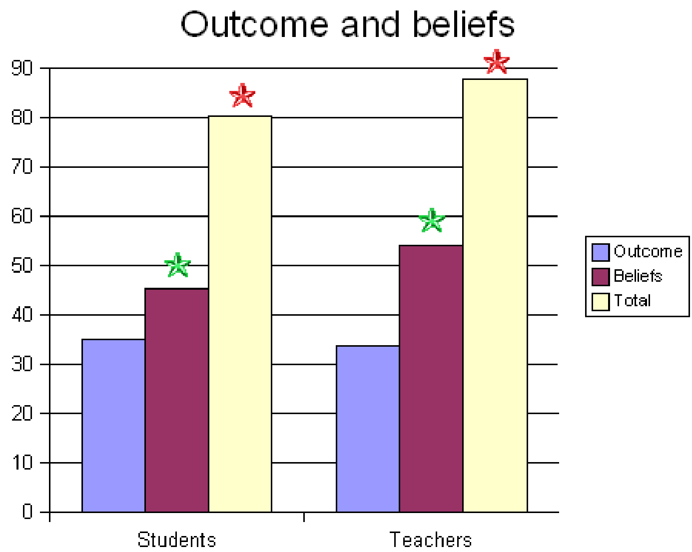


Fig. 21.3. Outcome and beliefs of students and teachers. Stars indicate the significant differences between students and teachers groups.

Despite the almost equal outcome expectancies, results from experiment #2 clearly indicate the significant differences in the beliefs potential between students and teachers what secondary influence also the total score. The study has shown that students have lower trust, beliefs in their own skills to be successfully applied for educational process. The teachers, on the other hand, believe in their skills and are also persuaded about the possible improvements of their teaching. Interestingly, the highest total score in teacher's group was 97 and the lowest 80; in the student's group the highest score was only 88 and the lowest only 74.

Conclusions and perspectives

University education, teaching and learning, are challenging parts of pedagogics. Practical investigations are usually performed in groups of variable sizes (5-200 students), on students studying different subjects (e.g. human, natural, social sciences, etc.), in different countries and different systems. Therefore, generalization and global improvements steps are almost impossible and results of different investigations cant, in most of the cases, be applied world-wide. On contrary, exploration of university pedagogic can offer a lot of possible approaches and tools which can be use under any of the mentioned conditions. One of these tools is also self-efficacy evaluation which may be applied for both, students and teachers, in investigating different aspect of educational process.

The first part of this project aimed on practicals in small groups (18 students) disclosed a surprising fact about the partial failure in the communication between the students and their teachers. After elaborating different hypothesis in the questionnaire, only questions focused on communication presented partially negative answers. Even though, students were satisfied with the course, and could somehow understand the topic, they did not comprehend all the parts of the practicals due to the missing will to ask, communicate with the teacher. On the other hand, its never only one-way line. Incomplete feed-back from students, could indicate limitations in use of teacher's personal skills by approaching the individual students, which is clearly possible in the small groups. Logically, the results from the first part evoke the hypothesis about communication discrepancies and enable further investigation of communication level between student and teacher, especially in quite uniform basic veterinary education.

Good communication between teachers and students results in optimal activation of students and encourage them to deliver the feed-backs. Moreover, interactions becomes more effective consequently leading to increase in the belief in one's skills and creating optimal base for personal development of both sites. The STEB test used in the second part of the study was aimed on disclosing the beliefs in student's-teacher's skills to reach the goal (successful learning and teaching process) and the personal assessment of outcome expectancies depending on teacher's performance. As expected from the group of selected teachers who most of them have a long term experiences in the university teaching, average total score was 87,86%, what corresponds to the results of other relevant studies. Very interesting is the low average score of student's beliefs (45,41). Obviously, the first year students in veterinary study have the difficulties to believe in their own skills to perform successful learning which may hamper them by further development. On the other hand, we can assume that this insecurity may be eliminated after a few successful exams, and after the initial period when they are getting used to study and learn in different environment. However, this fact, in my opinion, should be considered by scheduling the introductory course at the university. Resolving this "insecurity" may then have significant impact on communication between students and teachers later in the study and significantly influence the personal development of teachers and students.

Finally, we can conclude that the responsibility of the teacher is to support the communication with the students, guide them and encourage them to ask. This can in the high level influence their further development, as well as, help the teacher to improve skills used in university education.

A Appendix: STEBI1 test for teachers and students

The STEBI test is a valid and reliable tool for studying teacher's self-efficacy beliefs toward science teaching (Enochs and Riggs; 1990). The instrument presented below is a non-validated modification of the original STEBI test developed by Enochs and Riggs (1990). The modified STEBI test was developed by Robert Evans.

STEBI1 test for teaching efficacy - teachers

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement

SA	**strongly agree**	**UN**	**uncertain**	**D**	**disagree**
A	**agree**			**SD**	**strongly disagree**

1	when a student does better than usual in science, it is often because the professor exerted a little extra effort	SA A UN D SD
2	I will continually find better ways to teach science	SA A UN D SD
3	Even if i try very hard, I will not teach my next science course as well as i will most science courses	SA A UN D SD
4	When the science grades of students improve, it is often due to their professor having found a more effective teaching approach	SA A UN D SD
5	I know the steps necessary to teach science concepts effectively	SA A UN D SD
6	I will not be very effective in monitoring science experiments	SA A UN D SD
7	If students are underachieving in science, it is most likely due to ineffective science teaching	SA A UN D SD
8	I will generally teach science ineffectively	SA A UN D SD
9	The inadequacy of a student´s science background can be overcome by good teaching	SA A UN D SD
10	The low science achievement of students cannot generally be blamed on their professors	SA A UN D SD
11	When a low-achieving student progresses in science, it is usually due to extra attention given by the professor	SA A UN D SD
12	I understand science concepts well enough to be effective in teaching tertiary science	SA A UN D SD
13	Increased effort in science teaching produces little change in students´science achievement	SA A UN D SD
14	The professor is generally responsible for the achievement of students in science	SA A UN D SD
15	students´achievement in science is directly related to their professors effectiveness in science teaching	SA A UN D SD
16	If others comment that a student is showing more interest in science at university, it is probably die to the performance of the student´s professor.	SA A UN D SD
17	I will find it difficult to explain to students why science experiments work	SA A UN D SD
18	I will typically be able to answer students´ science questions	SA A UN D SD
19	I wonder if i will have the necessary skills to teach science	SA A UN D SD
20	Given a choice, i will not invite my supervisor to evaluate my science teaching	SA A UN D SD
21	When student has difficulty understanding a science concept, i will usually be at a loss as to how to help the student understand it better	SA A UN D SD
22	When teaching science, i will usually welcome students questions	SA A UN D SD
23	I do not know what to do to turn student on to science	SA A UN D SD

STEBI1 test for teaching efficacy - students

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA	**strongly agree**	**UN**	**uncertain**	**D**	**disagree**
A	**agree**			**SD**	**strongly disagree**

1	when I do better than usual in course, it is often because the professor exerted a little extra effort	SA A UN D SD
2	I will continually find better ways to study	SA A UN D SD
3	Even if i try very hard, I will not learn in my next course as much as i will most other courses	SA A UN D SD
4	When my course grades improve, it is often due to the professor having found a more effective teaching way	SA A UN D SD
5	I know the steps necessary to study veterinary science concepts effectively	SA A UN D SD
6	I will not be very effective in scheduling my learning process	SA A UN D SD
7	If I am underachieving in course, it is most likely due to ineffective teaching in the course	SA A UN D SD
8	I will generally learn science ineffectively	SA A UN D SD
9	The lack of my background in studied topic can be overcome by good teaching	SA A UN D SD
10	My bad course results cannot generally be blamed on my professors	SA A UN D SD
11	When a low-achieving student progresses in course, it is usually due to extra attention given by the professor	SA A UN D SD
12	I understand course concepts well enough to be effective in studying the topic	SA A UN D SD
13	Increased effort in course teaching produces little change in students´science achievement	SA A UN D SD
14	I am generally self responsible for the good results in the course	SA A UN D SD
15	My achievements in course are directly related to my professors effectiveness in teaching	SA A UN D SD
16	If others comment that a student is showing more interest in science at university, it is probably die to the performance of the student´s professor.	SA A UN D SD
17	I will find it difficult to understand the teacher explaining how experiments work	SA A UN D SD
18	I will typically be able to ask science questions in the course	SA A UN D SD
19	I wonder if i will have the necessary skills to learn veterinary science	SA A UN D SD
20	Given a choice, i will not invite my supervisor to evaluate my learning skills	SA A UN D SD
21	When student has difficulty understanding a topic, teacher will usually not be able to explain it	SA A UN D SD
22	When learning veterinary science, i like questioning in the lectures	SA A UN D SD
23	Professors do not know how to motivate student on to topic	SA A UN D SD

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