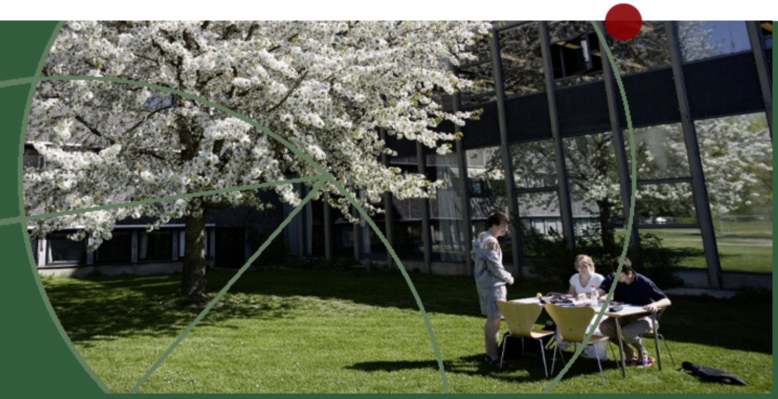
UNIVERSITY OF COPENHAGEN
DEPARTMENT OF SCIENCE EDUCATION



Improving University Science Teaching and Learning

Pedagogical Projects 2010

Volume 3, Number 1

Lars Ulriksen
Camilla Rump
Henriette Wase Hansen

This is number one in the third 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.

ISSN: 1904-2019

University of Copenhagen

Improving University Science Teaching and Learning – Pedagogical Projects 2010, vol. 3, no. 1

Improving University Science Teaching and Learning

Pedagogical Projects 2010

Department of Science Education
University of Copenhagen

Published by Department of Science Education, University of Copenhagen, Denmark

E-version at http://www.ind.ku.dk/publikationer/knud
Printed at www.lulu.com
Typeset in LaTeX

The anthology can be bought through the marketplace at http://www.lulu.com

Improving University Science Teaching and Learning – Pedagogical Projects 2010, vol. 3. number 1. ISSN: 1904-2000

Contents

1

Introduction

Lars Ulriksen and Camilla Rump

Department of Science Education

Introduction

This anthology presents papers reporting from projects that have aimed at developing the quality of the teaching and learning at the University of Copenhagen. The projects have been developed and carried out as a part of a teacher development programme (TDP) offered to academic staff across different faculties at the university. The programme consists of a practical part, where the participants' 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 continuously relate the theories of university teaching and student learning to their own courses and teaching environments, but particularly they inquire into their own practice of teaching in the two projects at the beginning and at the end of the programme: The former is related to student learning, and the latter is specifically aimed at the participants developing their own teaching.

This volume contains a number of these final projects that were carried out by the participants in the TDP in 2010/2011. For further description and information about the TDP, see (Christiansen et al.; 2009). The participants came with an array of different cultural and disciplinary backgrounds, as does the population of teachers and researchers in general at the university. Therefore, the course was given in English, as are the papers in the current volume.

The present volume is the fourth collection of papers presenting the works of the participants at this TDP. As in the previous volumes, the collection does not present scientific papers as such, but theoretically informed 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 they show us what they learn in the process. In this sense, the papers provide an insight into something that scientific papers often fail to show.

The papers present both successful experiments and experiments that failed or where the teacher considers that further development is needed. In fact, it is at the heart of the teachers' approaches to developing their teaching that the evaluation should have a formative purpose, suggesting ways forward, but only rarely do such accounts find their way to the peer-reviewed educational journals.

The themes of the papers reflect the conditions and challenges of present-day university teaching. There are papers addressing an increasingly diverse student body in the courses. This is partly related to a growing number of students from abroad attending courses at Danish universities, but this is not the only reason. Interdisciplinary courses and students moving across traditional borders between programmes mean that teachers cannot take for granted a particular body of prior knowledge. Some papers address the challenges facing a teacher who only teaches parts of a course, while others address the question of evaluating and developing entire courses. However, running as a common thread through the papers is a sincere dedication to improving student learning and providing the best possible conditions for students' engagement in teaching and learning activities.

When reading across the papers it is also possible to trace a shared focus on student learning outcomes rather than on the teachers' presentation of content matter, and an emphasis on the active participation of the students in the teaching. This reflects the inspiration from the teaching material used during the course, not least the concept of constructive alignment and of deep learning approaches (Biggs & Tang; 2007).

We have organized the papers of this volume in four parts according to shared themes, even though some papers address issues related to more than one theme:

1. Stimulating student activity and deep learning,
2. Lab work, exercises and group work
3. Diversity in students' backgrounds and
4. Evaluation and redesign of an entire course.

The individual contributions are introduced below.

Stimulating student activity and deep learning

Annette Eva Langkilde's paper concerns how to encourage students to engage actively in classroom exercises in a course in organic chemistry at the Faculty of Pharmaceutical Sciences. She focuses on establishing shared expectations between students and teachers and she addresses how students can be guided towards a deep learning approach focusing on understanding rather than through training specific exercises. Further, she emphasizes how the atmosphere of the class has an impact on students' learning possibilities and enhancing their self-efficacy.

In her paper, Vanessa Hall the design, implementation and evaluation of a number of integrated motivational activities for large lecture groups, in this case classes in anatomy and physiology in a veterinary study programme with approximately 180 students. Since the number of students in the class may rise even further, it is of immediate importance to design and evaluate relevant and motivational learning activities for large class sizes. Following a review of three different interactive tools – clickers, flash cards and quizzes – which have been tried out mainly in American universities and rarely in veterinary programmes, Hall tried out two of the techniques (flash cards and clickers) in her own class and evaluated their effectiveness. For both clickers and flash cards she finds that the benefits clearly outweigh the disadvantages, and she provides some tips and tricks for further use. The question of dissemination to the whole programme faculty is discussed.

Brian Møller Andersen evaluates his new design of a graduate physics course on condensed matter theory introducing lessons where shorter periods of (interactive) lecturing of no more than 15-20 minutes are intertwined with different student activities of shorter (a few minutes) or longer (20-30 minutes) duration. One part of the evaluation is a systematic comparison of the effectiveness of the two formats: the traditional format and the redesigned format. For both formats, the students were given a test of understanding after four 45-minute lessons. With a reservation due to the limited number of students, the test results provide a surprising, but quite convincingly higher result from the redesigned course format than the traditional one. Furthermore, the questionnaire evaluations from the students show support for the new format from 80% of the students.

The paper of Arne Henningsen presents the design of a course in agribusiness economics for the MSc programme in Agricultural Economics. The course design focused on encouraging active student participation and on deep learning. It applied problem-based learning as the basic teaching format and emphasized dialogue in the lecture sequences. The course contained weekly group assignments that also served as the starting point for the final oral examination. The group assignments were peer-reviewed by other groups and the peer comments could be used for revision of the handed-in assignments. The paper provides examples of other kinds of active participation and of addressing the problem of gaps in students' prior knowledge. The overall result of the design was good in relation to both student learning and the author's experience as a teacher. There were, however, some students who were critical of the format and who demanded a more traditional format.

In her paper, Gitte Erbs addresses the question of how it is possible to provide a productive learning environment for students when the teacher teaches just once or twice during an entire multi-departmental and multi-teacher course. Among the challenges are that the students experience highly diverse teaching, and that it may be difficult for a teacher who teaches a single lecture to involve students if they are not used to being involved. Erbs describes how, for a second-year course in microbiology, she organized a lecture with an emphasis on student involvement. Based on her own experience with the teaching and on the feedback from the students she concludes that it is possible – within these restrictions – to engage students in interactive lectures even within the frame of a 'one-lecture stand'.

Henrik Lütken reports on a joint BSc and MSc course in seed science where he teaches three half days on a topic concerning gene manipulated crop (GMO) seeds. His aim was to increase student motivation and activity and to stimulate deep learning approaches through interactive lectures, small assignments, buzzing in pairs and other short activities. He experienced that these measures eventually led to increased activity. The course was taught twice for two different groups of students (one purely international and one of mixed Danish and international students), and Lütken explores whether the design has a different impact for the two groups. He finds that both groups of students preferred the interactive lecture format to the traditional, and that the students participated more actively than before. Still, he points to the importance of adjusting the lecturing to different groups of participants. This paper, therefore, also relates to the third theme on students' backgrounds

Pernille Kæstel's project deals with the issue of assessment and examination. Taking her point of departure in the pivotal role that examination and assessment play in the students' learning approaches and learning outcome, she discusses the development of the assessment format in a postgraduate course on nutrition and health at LIFE. The changes aimed at focusing the examination and the students' attention on understanding rather than recollecting and to more generic academic competences. This was done, for instance, through the formulation of different types of question. Further, she shows how they aimed at increasing the alignment of the course, and providing the students with access to the assessment criteria. This was done, inter alia, through the construction of a rubric that states the criteria for obtaining different grades. Finally, she comments that the further development may involve changes in the intended learning outcomes.

Lab work, exercises and group work

Anders Ø. Madsen's paper deals with a mathematics course for biochemistry students. Since the course is a 'tool-box course' for five study programmes, there are several restrictions on the design, including a common exam across all programmes and a core set of compulsory assignments to be solved by the students. A central challenge of motivation for the biochemistry students is that the outcome description of the biochemistry programme does not mention mathematics at all, as it is close to impossible to make contextualized mathematics assignment in biochemistry at that level (first-year, first-semester Bachelor's course). In order to meet this challenge and the general scarcity of student activity in traditional problem-solving classes, Madsen designed a number of experiments to meet these challenges. The experiments were quite successful in promoting another atmosphere of learning in the classroom. However, time pressure and an assessment based on multiple-choice tests, as well as large differences in the abilities of the students, caused a *backwash* effect that is hard to circumvent without realigning the course with a new type of assessment.

In his paper, Anan Yaghmur presents results from an extensive questionnaire survey of students' experience of a series of laboratory exercises they completed in a course in physical chemistry for pharmaceutical science students. The questionnaire addresses questions of student preparedness, their experience in the lab, their experience of writing the report and the learning outcome they experienced from these activities. The results show that students' preparation for the labs is insufficient, but even so their experienced learning outcome after having completed the reports is quite good. The students prefer laboratory exercises with an immediate pharmaceutical relevance. Suggestions for how to improve student preparedness are given.

Annie Høgh presents her experiences with letting students do small in-class presentations of parts of the curriculum. The idea was to make the students study the compulsory literature of the course, but since the format of the presentations resembled the format of the exam they also prepared the students for the examination requirements. Further, the paper reports experiments with letting the students work with cases or problems where they were to use the theories and models that were presented.

The paper by Alberto Grossi evaluates the role of group work in student learning, in a course on physical and chemical changes of food quality. The group work is mainly done in relation to the practical work in the course. The evaluation is based partly on a thorough analysis of the alignment of the course and partly on a questionnaire survey of the students' experience of the actual group work in the course. The analysis shows a good alignment of the course, and the questionnaire shows that students were in general satisfied with the group work and thought it was a positive experience. Even so, one-third of the students do not consider that it is an advantage to have students of different nationalities and different educational background in the group. This suggests a need for more group reflections on the group work process and a more explicit focus on opportunities for the development of group working skills. Hence, this paper is a bridge to the next section of this volume.

Diversity in students' backgrounds

The paper of Alicia Budek Mark and Lesli Hingstrup Larsen addresses the issue of second-language teaching and learning. An increase in failure rate was observed when the language of instruction of a graduate course in nutrition physiology was changed from Danish to English. Mark and Larsen involved the university's Centre for Internationalization and Parallel Language in the introductory week of the programme by offering the students a test of their English skills and an optional language course, and then designed, implemented and evaluated a teaching and learning activity based on peer feedback on an exam-assignment example and reflection on language skills. The question of the potential for different challenges for students with the background of a professional Bachelor's degree and students with a university Bachelor's degree was considered, but no significant differences were found. Overall, the activity was found to be successful in that the students experienced benefit from the activities, and the failure rate dropped dramatically. With respect to the latter, reservations are expressed with respect to differences in the two student cohorts. The authors decided to continue to use and develop the activity.

Mingshi Yang studies a particular course in a Master's programme in pharmaceutical sciences. The students on the course come from diverse disciplinary backgrounds and have chosen different lines of specialization. On the basis of a questionnaire addressing the students' expectations prior to the course and the students' evaluation halfway through, he discusses the importance of paying attention to the students' background, and he points out how some of the course elements need further development to further increase internal alignment and in order to take the students' different backgrounds and interests more into consideration.

In her paper, Sine Lo Svenningsen investigates the challenges of teaching a course that is interdisciplinary not only in content, but also in the group of participating students and the teachers teaching the course. Based on a thorough and critically reflected discussion of students' evaluations of the first run of the course and of her own experiences, she makes the important – and by no means trivial point – that interdisciplinary courses should be taught in an interdisciplinary way and that this requires considerable effort from the teachers. Also, she points out that the assessment provides a particular problem when both course content and the students come from diverse disciplinary backgrounds. Finally, the paper discusses how the development of the research discipline in question presents the study programmes with new challenges concerning the curriculum and the traditional borders between disciplines.

Evaluation and redesign of an entire course

Derek V. Byrne examines a popular and well evaluated course in sensory and consumer science by means of a questionnaire and a focus group interview. He focuses on alignment – internally within the course between ILOs, TLAs and assessment and externally between the course ILOs, the programme ILOs, and students' future work. The course has continuously received top evaluations from the students, and the focus of the inquiry is to learn what in the course makes it good, and to improve the course further. The analysis shows that the students experience the course as well aligned internally and in general they found the teaching and learning activities meaningful and useful. The students found that the project played an essential role in the course, and in general they appreciate the holistic structure of the course. It is argued that all lecturers should state their intended learning outcomes explicitly, and a new week plan is suggested.

Michael Timm presents experiences from redesigning an elective Master's course on quality control in the pharmaceutical sciences. The intention was, inter alia, to draw the methods used closer to those applied in the industry and to increase the independent student work by reorganising the exercises in a problem-based learning (PBL) format. The students were to analyze two pharmaceuticals instead of doing separate "cookbook" exercises, they were required to study original literature, and specialists from the industry were invited give lectures. The paper discusses the changing role of teachers, not least the difficulty of finding a balance in letting the students work independently without appearing unapproachable or uninterested. Generally, the students were able to meet the challenges of the more open and demanding format.

Part I

Stimulating student activity and deep learning

2

The first lesson in the classroom – getting students engaged in active learning process

Annette Eva Langkilde

Department of Medicinal Chemistry, FARMA, University of Copenhagen

Introduction

The aim of this project was to search for alternative ways of encouraging the students to take an active part in the classroom, and to break from the traditional walk-through of exercises on the blackboard.

The focus in this report is on the initiatives made for the first session, as I believe the impressions from the first encounter have a crucial impact on the rest of the course programme. If the students walk away from the first session with a good "feeling" of being capable, and at the same time getting something out of showing up and participating, the positive attitude will affect the following lessons.

Description of the course

Organic Chemistry I (M31) is a mandatory course in the first semester for all students at the Faculty of Pharmaceutical Sciences. The official course description (in Danish) is included in Appendix A. The course consists of lectures with 200-250 students, classroom exercises with 30 students per class (i.e., eight more or less parallel classes). In addition, a study-café is held five times during the semester, with older students being available for help in three connected courses. A second part of the course in the following semester also included practical laboratory exercises.

The content of this project is focused on the classroom exercises, which I have taught, with particular focus on the first lesson. The classroom teaching is organized as twelve double lessons (2×45 min) of which one involves specific exercises at computers. In the following, I will use the term first lesson to refer to the first double lesson (i.e., 2×45 min). Suggested exercises are chosen by the teacher responsible for the course, and the classroom teachers meet prior to the start of the course to discuss possible approaches to the classroom teaching and their previous experiences.

Generally, Organic Chemistry is a course the students evaluate positively and the students are generally motivated, despite the fact that it may well be considered a tool-box course.

Initial plans and aims for the first lesson

- Questionnaire and a general discussion on mutual expectations. Questionnaire first to give the individual student a moment to think about his/her own expectations before a general discussion.
- Introduce myself: name, affiliation, teaching experience, motivation, taking part in a pedagogical course.
- Learn student names (or at least start to).
- Student activity. Play the game cards. See a more detailed description below.
- Evaluate the game. Ask students what they successfully explained to each other and what is still problematic. Did they like the cards?
- Close unresolved questions in a general discussion by the end of the lesson.

Overall aim: Set the scene for high level of student activity and a good atmosphere for the learning process.

The game cards

Inspired by a group of students attending the course last year, we (the team of classroom teachers for the course) made a card game for the final session before the summer break (i.e., the second part of the organic chemistry course). Several of the students mentioned it would have been great to do this earlier. Thus, this was the inspiration for this part of the project.

The aim is to work through the planned exercises as game cards in small groups of four or five students. The group is given a set of cards, and without using their books (or at least only after a thorough discussion) the students take turn in picking a card with a question. The student should not

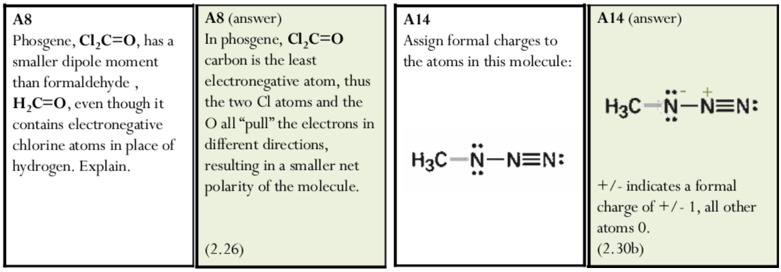


Fig. 2.1. Examples of two game cards from the first lesson. See more in Appendix B.

only answer but also explain how or why he or she arrived at this answer. If needed, the group may help and finally the answer can be checked on the back of the cards. To keep a positive atmosphere, the level of competition is left up to the individual group, and no winners or losers are announced.

As the suggested exercises for the classroom teaching were posted on the course homepage prior to the lesson, I decided to base the questions on the game cards (see above and Appendix C) on these exercises. I chose this to avoid well prepared students feeling their preparation was superfluous, but instead to reinforce the well prepared students' self-efficacy as they experienced improved understanding and ability to explain to their peers thanks to their preparation. Turning it into a game should give all group members a chance to be the one to explain (as they take turns in picking random cards) and a bit of fun may even stimulate the intrinsic value for the student.

My role during this game (as well as later sessions with group work) is not to give the answers when asked, but try to assist the students in finding the answer themselves.

Implementation

The first lesson was attended by 28 students (of 30 listed). Overall, the plan was followed, though I chose to start the name-learning as the groups were "playing", as this gave me a chance to interact a bit more closely and add a few names to the faces at the same time.

The students were very willing to answer the questionnaire. They had several and very widespread suggestions as to what they would like during the classroom teaching, including the “classic” teacher-go-through-all-exercises-at-the-blackboard-while-we-(passively)-take-notes scenario, which was the only thing I ruled out on the spot.

Regarding the card game, the students engaged in great discussions, while I circulated among the groups, on request to assist or on my own initiative to “listen in” and learn names.

All in all, there was a very positive atmosphere and I left feeling motivated for the lessons to come.

Evaluation

The course was taught during the autumn of 2010, and as the Bachelor’s degree part of the studies at the Faculty of Pharmaceutical Sciences is still running over semesters, the students had not yet sat the exam for this course (scheduled for January 2011). Thus the evaluation is based on student feedback (primarily from the first and last lessons) as well as my own reflections (from both the first session and the overall course programme).

The first encounter

Student responses on expectations and my comments

I prepaired and distributed a small questionnaire[1] to give me written responses as well as to give the students a moment to think about their own expectations before a general discussion and also an opportunity to comment anonymously. The second half of the questionnaire focused on a statement from the course homepage on our (the teachers’) general expectations.

A large part of the students would prefer the teacher to go through all exercises, which was also mentioned in the following general discussion. Slightly contradictory to this, the majority also thought students should go through the exercises.

The group was completely split on the question of working with the exercises and syllabus during the lessons. Thus this is a point where it will be

[1] The questionnaire handed out to the students was in Danish.

	Strongly disagree	Disagree	Agree	Strongly agree
The teacher is prepared for the class	0	1	5	21
The teacher go through all exercises	0	10	14	3
The teacher go through selected exercises	1	4	11	12
Students have solved (or attempted to solve) all exercises prior to the lesson	0	0	11	16
Students work with the exercises/syllabus during the lessons	3	10	12	2
Students go through exercises	2	4	16	4
I'll be (expect to be) prepared for the lessons	0	1	11	15
I expect to participate in all lessons	0	0	12	15
I'll choose lessons depending on theme or other...	7	15	3	0

Fig. 2.2. Answers from the first part of the questionnaire.

challenging to please everybody. However, it is in this scenario that much is learned and it is part of the "official" aim of these lessons that in some form will be a large part of the sessions. In the general discussion, I received several good comments on how this could be done, many of which were implemented or tested during the course programme, e.g. prioritize the suggested exercises at the beginning of the session or after the group work session, then discuss in this order, to address the most difficult first.

The second part of the questionnaire included a statement from the course homepage (Appendix B), concerning some general expectations from the course organizers/teachers on how the classroom lessons will run. I had previously assumed that all the students had read this, but for this class, I printed the statement on the second page of the questionnaire (i.e. not visible when answering the first part) and asked:

1. Have you read this statement from the course homepage?
2. Has it changed your expectations?

There was room for additional comments.

Much to my surprise, only half of the students had actually read the statement. One commented that she knew about it (presumably from other students) and thus it did not change her expectations.

The fact that most students (20) say that this statement had not changed their expectations suggests that the students have had very similar expectations, which is not really reflected in the fact that the majority expect me as teacher to go through all the exercises as seen from the first half of this questionnaire. Alternatively, they still hold on to whatever expectations they have regardless of this statement. In any case, it prompted a fruitful discussion during our first session.

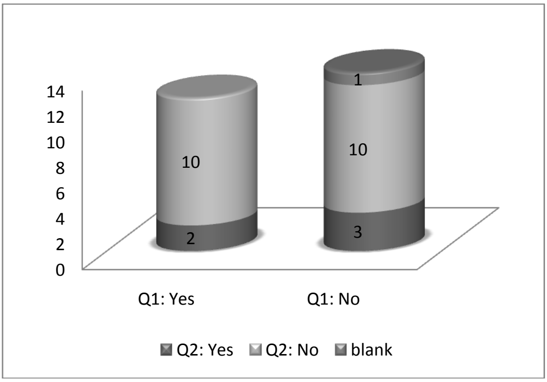


Fig. 2.3. The answers to the questions regarding the statement written on the course homepage.

Playing the game

The response to the game was very enthusiastic and the students took on the challenge with no complains. The game format, with a loose rule of no books (or as limited reference to books as possible) prompted more peer discussion and less flipping around in the books. I was circling the groups, sometimes on request, but just as often on my initiative, as the students resolved most issues in the groups.

The immediate evaluation was very positive, in terms of successful experiences with having explained things to peers and having understood something from the group. Most of the groups struggled to come up with an unresolved question. Perhaps this reflected the exercises being at the easy end of the scale, with some exercises summarizing a few things from their high-school syllabus.

In the end, by focusing on what was explained well by peers, hopefully the students self-efficacy in smaller groups had increased, thereby the students should be more likely to participate in full class discussions. Also by not forgetting to close the lessons with a general discussion on the final unresolved issues the aim is that the students walk away from the class, feeling like they “got something out of it”, i.e., increased (or at least attained) the value of these lessons for the individual student.

Reflections based on the entire course program

Previously, when I have taught this course (12 double lessons) I have experienced very low attendance rates – at worst two students. Although this class coincided with project work in another course, it was still not very motivating). The group of teachers involved in the course, have introduced group work as a major part of the classroom lessons, but I felt reluctance towards this from a majority of the students, and several kept asking for the traditional walk-though of exercises.

With this class from autumn 2010, my experiences have generally been much more positive. The attendance rate has also been high (mostly 20+ students), the lowest being the lessons from 8-10AM with no other lessons scheduled with twelve students attending. Of course, other factors may have a significant influence on this; i.e. I think the coordination with other courses has improved. Project work with hard deadlines in other courses was at least part of the reason for the very low attendance rate experienced previously.

Throughout the course the students have been free to form groups as they pleased, and in connection with a supervision session I noted how these group formations were more dynamic than I expected and had previously noticed. The students are not sitting with the same group every time. According to Biggs and Tang ((2007)), referring to Yamane, there would be a higher likelihood of gossip and off-task discussion in this kind of free-formed groups. I have not (yet) compared them with the discussion level in groups that I have chosen, but I have been impressed thoughout the course with the level of discussion among the students and the enthusiasm they have shown towards the work. It has not been easy to enforce breaks between the two connected 45 min lessons, as students continued to ask questions, in groups and individually.

Throughout the course the students have given feedback in a very positive tone, on what they liked/disliked, resulting in many smaller variations throughout the programme. Generally, at least half of the time has been dedicated to group work and discussions, while there have been variations in how much time was spent before or after on general introduction and discussion or students going through exercises at the blackboard.

When it comes to the students at the blackboard, it was dominated for quite some time by just a few students volunteering. Inspired by the pedagogical supervision during one of the lessons, we tried assigning different exercises to groups which raised the amount of students actively participating at the blackboard. This can still be improved, however.

As a last aspect, I also realize that I am still struggling slightly with the concept of coverage. It is described by Biggs and Tang (2007, p. 40) in terms of students being overloaded, but I sometimes feel some guilt (for want of a better word) when I have not discussed all the problems. I am convinced that the deeper approach and detailed discussion of a single or fewer problems is more valuable than a list of answers with a quick or no explanation, but I believe the residual struggle is a result of the way I was most often taught (we or the teacher did go through all listed exercises at the blackboard). Thus the ongoing task is to keep encouraging a deep approach to learning. This can be done, for example, by showing students what they can gain from understanding the basic principles of a chemical reaction instead of learning how to solve specific types of exercises, showing that with the basic principles one can "recognize" this in most reactions and then be able to predict the product in reaction types that are new to the student.

Conclusions

I found that the open discussion of the students' expectations was very useful and we had smaller similar sessions throughout the course. Assuming we all know at least has not worked for me before. It may take up time from the exercises, but this is time well spent! The students gain more ownership as they have a large influence on the format. When asked for feedback at the end of the course, where I assumed they would remember the game from the first lesson, several marked the discussion of expectations as a key element from the first lesson.

I have used group work or learning cells throughout the course, mainly to have the students take an active part in the learning process, in discussions with their peers. Formulating what they do not understand and explaining subjects to others are both challenging and useful exercises.

As the hours allocated to this course have been decreased, there are no longer hand-in exercises in this course, thus an advantage of the group work during class is that it also gives me as the teacher an opportunity to better follow the individual student and know their capabilities better. The interaction with a small group allows me to follow the individual's expressions and notes, and some students may feel more free to ask questions or ask for alternative explanations when with a small group. Thus, overall, I get a more nuanced picture of the capabilities in the class than I would have from the "classic" blackboard teaching.

The card game was a successful ice-breaker in the first session and illustrated some important points of group work. Games like this are not to be used all the time, but may help engage the students. I had originally planned to use it more times, and even had the cards prepared once, where the students chose to work differently with the problems. For that given lesson, I had misjudged the capabilities and needs of the students and thus adjusted accordingly. However, I have searched for more inspiration from other games, e.g. Chemistry Taboo (Capps (2008) and references herein) and Where's Ester (Angelin & Ramström; 2010) and believed that a few varied sessions like this could be helpful in many ways as this card game was for this group of students.

There are many more aspects to the classroom teaching that I have not touched upon here, but doing this project work and searching through literature for it I found much more inspiration, e.g. on how to employ "minute papers" and "fish bowls" (as described and further referenced in Paulson, 1999). Some of all this inspiration will be implemented in the coming semester where I look forward to continue teaching the same group of student more organic chemistry.

A Course description in Danish

From August 2010.

Praktiske oplysninger

Status: Obligatorisk på bacheloruddannelsen i farmaci
Tidspunkt: 1. semester - efterår
Undervisningsform: Forelæsninger og klasselektioner. Undervisningen støttes af hjemmeopgaver.
Kursusomfang: 6,5 ECTS-points
Timetal: 24 forelæsninger á 45 min. og 24 klasselektioner á 45 min. (afholdes som 12 dobbeltlektioner)
Frekvens: 1 gang årligt
Prøve:

- Prøveform: Skriftlig prøve af 2 timers varighed
- Bedømmelse: Bestået/ikke bestået
- Bedømmere: Faglærer(e) uden medvirken af censor
- Tilladte hjælpemidler: Brug af molekylmodelbyggesæt ellers ingen
- Særlige forhold: Prøven, der er en del af 1.årsprøven, afholdes i januar.

Reprøve afholdes lige før eller lige efter påske, jvfr. regler om 1.årsprøven.
Undervisningsmateriale: J. McMurry: Organic Chemistry with Biological Application. 2nd ed. 2011, Brooks/Cole
Sprog: Dansk

Formål

Kurset har til formål at indføre den studerende i de grundlæggende begreber inden for organisk kemi, herunder:

- Simple organiske forbindelsers molekylstruktur
- Basal stereokemi
- Enkelte kemiske reaktioner og deres reaktionsmekanismer, så som addition, elimination, nukleofil substitution og nukleofil addition til carbonylgrupper
- Tolkning af IR- og 1. ordens 1H-NMR-spektre.

Indhold

Kurset består af 24 forelæsninger og 24 klassetimer (som dobbelttimer).

I forlæsningerne gennemgås stoftyperne: alkaner, cykloalkaner, alkener, alkyner, aromatiske carbonhydrider, alkylhalider, alkoholer, phenoler, thioler, ethere, sulfider og oxoforbindelser. For hver stoftype berøres: molekylstruktur (herunder stereokemi og resonansformer), fremstilling, fysiske egenskaber og kemiske reaktioner. I forbindelse med de kemiske reaktioner gennemgås mekanismerne for: addition, elimination og substitution. Endvidere vil forelæsningerne omfatte introduktion til UV-, IR- og 1H-NMR-spektroskopi. I klasselektionerne arbejdes med opgaver til understøttelse af det teoretiske pensum. Endvidere vil de studerende blive trænet i at tolke IR- og 1. ordens 1H-NMR-spektre. I forbindelse med klassetimerne tilbydes 2 hjemmeopgavesæt, hvoraf det sidste opgavesæt er et eksempel på et eksamenssæt.

Formeltegningsprogrammet ChemBioDraw vil blive introduceret i en dobbeltlektion.

Målbeskrivelse

Efter kurset skal den studerende

- Kunne redegøre for de i pensum omtalte stoftypers opbygning og deres systematiske navngivning
- Kunne opskrive konstitutions- og konfigurationsformler for simple organiske forbindelser ud fra deres systematiske navne
- Kunne redegøre for de i pensum omtalte reaktioner og deres reaktionsmekanismer
- Kunne redegøre for oprindelsen og udseendet af signaler i UV-, IR- og 1. ordens 1H-NMR-spektre.

De nævnte kundskaber skal kunne anvendes med henblik på

- At navngive simple organiske stoffer efter IUPAC-reglerne
- At beskrive et stofs struktur, herunder molekylgeometri, relativ og absolut konfiguration samt isomeri-muligheder
- At skønne over et stofs fysiske egenskaber, herunder opløselighed, smeltepunkt og kogepunkt, på basis af molekylstruktur
- At foreslå reagenser til gennemførelse af kemiske reaktioner
- At forudsige forløbet af simple reaktioner
- At kunne udlede strukturen af simple organiske forbindelser ud fra stoffets IR- samt 1H-NMR-spektre.

Studenterbelastning

	Antal timer
Forelæsning	24
Forberedelse	48
Klassetimer	24
Forberedelse	48
Eksamen og eksamensforberedelse	35
Totalt antal timer	179

Kursusansvarlig

Bente Frølund, Institut for Medicinalkemi

B Quote from the M31 course homepage (in Danish as originally stated)

> *Klassetimer*
> Klassetimerne er et forum, hvor du som studerende selv skal arbejde med stoffet.
>
> Til hver klassetime vil der være foreslået et vist antal opgaver, som relaterer sig til det gennemgåede pensum i forelæsningerne.
>
> *Opgaverne skal forsøges løst inden klassetimerne*
> For at opnå optimalt udbytte af klassetimerne er undervisningen baseret på at opgaverne er forsøgt løst inden klassetimen, evt. sammen i mindre læsegrupper. Klassetimerne skal bruges til at få afklaret specielt vanskelige opgaver.
>
> *Løsninger på opgaver kan findes i Study Guide*
> Det kan ikke forventes at alle opgaverne bliver løst i løbet af klassetimerne. Løsninger til opgaver fra lærebogen: ‘Organic Chemistry with Biological Applications’ kan findes i den tilhørende Study Guide. Study Guiden kan evt. lånes på bibliotektet eller købes, evt. sammen i læsegrupperne.

Translation of the statement from the course homepage:

Classroom lessons
The classroom lessons represent a forum where students themselves work with the syllabus.

For each class lesson a number of problems or assignments that relate to the syllabus of the lessons will be proposed.

The problems should be attempted solved before the lessons
To obtain optimal yield of class lessons, teaching is based on the assignments having been tackled before class lessons, possibly in small reading groups. Class lessons are aimed at clarifying particularly difficult problems.

Solutions to the assignments can be found in the Study Guide
It cannot be expected that all assignments are solved during class hours. Solutions to assignments from the textbook 'Organic Chemistry med Biological Applications' can be found in the corresponding Study Guide. The Study Guide may be borrowed from libraries or purchased, e.g. together in reading groups.

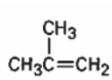
C Examples of game cards used in the classroom

The cards were printed two-sided (Question/Answer):

A1
State the expected hybridization for each C atom in this compound:

$CH_3CH_2CH_3$

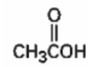
A2
State the expected hybridization for each C atom in this compound:



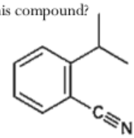
A3
State the expected hybridization for each C atom in this compound:

$H_2C{=}CH{-}C{\equiv}CH$

A4
State the expected hybridization for each C atom in this compound:

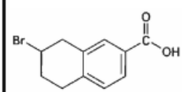


A5
How many hydrogens are bound to the C atoms in this compound?



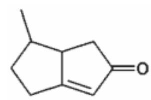
… and state the molecular formula of the compound.

A6
How many hydrogens are bound to the C atoms in this compound?



… and state the molecular formula of the compound.

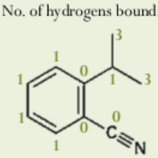
A7
How many hydrogens are bound to the C atoms in this compound?



… and state the molecular formula of the compound.

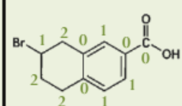
A8
Phosgene, **$Cl_2C{=}O$**, has a smaller dipole moment than formaldehyde , **$H_2C{=}O$**, even though it contains electronegative chlorine atoms in place of hydrogen. Explain.

A5 (answer)
No. of hydrogens bound:



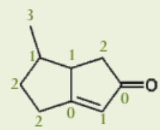
Molecular formula:
$C_{10}H_{11}N$
(1.42a)

A6 (answer)
No. of hydrogens bound:



Molecular formula:
$C_{11}H_{11}O_2Br$
(1.42a)

A7 (answer)
No. of hydrogens bound:

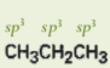


Molecular formula:
$C_9H_{12}O$
(1.42a)

A8 (answer)
In phosgene, **$Cl_2C{=}O$** carbon is the least electronegative atom, thus the two Cl atoms and the O all "pull" the electrons in different directions, resulting in a smaller net polarity of the molecule.

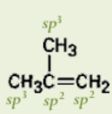
(2.26)

A1 (answer)
Expected hybridization of C atoms:



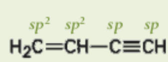
(1.33 a)

A2 (answer)
Expected hybridization of C atoms:



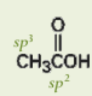
(1.33 b)

A3 (answer)
Expected hybridization of C atoms:

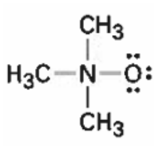
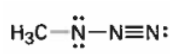
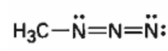
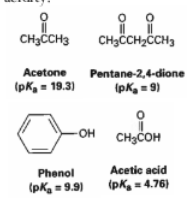


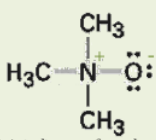
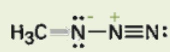
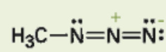
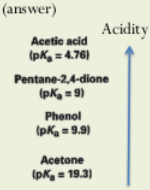
(1.33 c)

A4 (answer)
Expected hybridization of C atoms:



(1.33 d)

A9 Which bond is more polar? Indicate the direction of bond polarity for each compound. **H_3C–Cl** or **Cl–Cl** Use the electronegativity table.	**A10** Which bond is more polar? Indicate the direction of bond polarity for each compound. **H_3C–H** or **H–Cl** Use the electronegativity table.	**A11** Which bond is more polar? Indicate the direction of bond polarity for each compound. **HO–CH_3** or **$(CH_3)_3$Si–CH_3** Use the electronegativity table.	**A12** Which bond is more polar? Indicate the direction of bond polarity for each compound. **H_3C–Li** or **Li–OH** Use the electronegativity table.
A13 Assign formal charges to the atoms in this molecule: 	**A14** Assign formal charges to the atoms in this molecule: 	**A15** Assign formal charges to the atoms in this molecule: 	**A16** Rank in order of increasing acidity: 

A13 (answer)  +/- indicates a formal charge of +/- 1, all other atoms 0. (2.30a)	**A14** (answer)  +/- indicates a formal charge of +/- 1, all other atoms 0. (2.30b)	**A15** (answer)  +/- indicates a formal charge of +/- 1, all other atoms 0. (2.30c)	**A16** (answer)  A lower pKa value indicates a stronger acid (2.38)
A9 (answer) δ^+ δ^- **H_3C–Cl** most polar +→ **Cl–Cl** Non-polar (2.28a)	**A10** (answer) **H_3C–H** Non polar (EN difference <0.4) δ^+ δ^- **H–Cl** most polar +→ (2.28b)	**A11** (answer) δ^- δ^+ **HO–CH_3** most polar ←+ δ^+ δ^- **$(CH_3)_3$Si–CH_3** +→ Larger difference in EN, more polar (2.28c)	**A12** (answer) δ^- δ^+ **H_3C–Li** ←+ δ^+ δ^- **Li–OH** most polar +→ Larger difference in EN, more polar (2.28d)

3

Integration of novel motivational teaching tools for large lecture sizes

Vanessa Hall

Department of Basic Animal and Veterinary Sciences, LIFE, University of Copenhagen

Introduction

Class entry sizes for Veterinary Science at the Faculty of Life Sciences (University of Copenhagen) have been increasing annually the last few years and may continue to do so in the coming years. The size of the current first-year class is 186. I have been involved in teaching components of a first-year course, Anatomy and Physiology II to these students. The course includes lectures, practical demonstrations and exercises. The lectures, practical demonstrations and exercises, both microscopic and macroscopic, are performed by the whole year group at the same time, either in a single lecture hall, the large histology rooms or in a single dissection hall. For more details of the course information, see link: http://www.kursusinfo.life.ku.dk/Kurser/300059.aspx (from University of Copenhagen website).

The current teaching methods employed for lectures within this course are based on standard school lecture principles. That is, lectures are designed as monologue-teaching with PowerPoint presentation from a single teacher to a large hall containing 186 students. The amount of anatomical structures and Latin names that need to be learned and memorized are extensive. From my own observations, attendance at lectures is not at full capacity. This may be due to a lack of motivation and difficulties in learning in such large-scale teaching environments. From my own experience at another university and participation in large lectures with over 200 students, I found the teaching to be un-motivating and I was easily distracted. When questions are posed in large lectures, the student answering may be difficult to hear (due to distance) and participation is limited to a single individual in the class (and usually only the confident students who are not scared to answer). As student class sizes continue to grow, it should be expected that our teaching styles will adapt accordingly to maximize the learning outcomes and provide high-quality teaching, which keeps the students motivated in what could be considered an un-motivating scenario for many of them. This lack of motivation may stem from one or more of the following: little personal interaction with teachers, difficulty to express and provide feedback or questions, or a general feeling of students being distant from the education programme and the teachers, in general.

Proposal

It would be useful to integrate more modern teaching approaches to improve the participation of the students in learning, to improve their motivation and ultimately yo increase their learning capacity and to be interested in and want to attend all the lectures. In this project, I will analyse the pros and cons of different interactive tools for teaching in large environments. I will reflect on my own teaching experience where I applied two such tools. I will also reflect on how to integrate, in a practical sense, these tools in such classes (taking into consideration, the "selling" of these techniques to other teachers and the teaching coordinator as well as the current departmental budgets). I will also try to contact other universities (mostly based in the United States) employing such interactive tools in their teaching and obtain feedback about implementation and usefulness of these tools in their curriculum.

Overview and definition of novel interactive tools

In this paper, I will review three different interactive tools which are applicable in large lecture teaching: 1. Clickers 2. Flash Cards 3. Interactive quizzes. Some simple definitions of these tools are as follows:

Clickers

Clickers (also known as Classroom Response Systems (CRS)) are simple electronic handheld devices used by students to send electronic (infrared) responses to the teacher. The device may allow at least two different options that the students can choose from (usually they have multiple options). Therefore, the question posed by the teacher must be constructed to include at least two different possible answers that the students must decide between. The feedback is directed back to the software and to the teacher's computer and may be reported immediately back to the students, often shown as a graph in percentage of answers for either A, B etc. Most often, the responses made are anonymous, however, in some clicker packages software the teacher can choose to track the responses from individuals over time. The use of clickers has been growing rapidly, in particular in the United States with the Interwrite PRS RF clicker adopted at the University of Delawere, and the iClicker at Colorado State University, the University of Miami and the University of Alberta. Ohio University and the University of Utah currently use Turning Point clickers, which includes Turning Technology software that can be used through a dedicated clicker, or the students' own smart phone or mobile phone. University of Iowa is using a clicker called ResponseCard.

Flash cards

Flash cards are a low-technology alternative to clickers and generally include colour, text or image cards that students can raise order to respond to directed interactive questions during the class. As in the case of clickers, these are used to respond to multiple-choice questions. Generally there are at least two card alternatives to choose from. Some booklets are available with a number of different response alternatives to choose between.

Quizzes

Quizzes are a set of written questions given to pairs or individual students and may be developed in varying ways. Effectiveness in large classes may mean adaptation of quiz styles to reflect the class size. Feedback may or may not be given directly in class. To be considered an interactive tool, responses should be given and discussed during class.

Pros and cons of novel interactive tools

Clickers

Pros

There are a number of features in using clickers that are considered advantageous. One is that they give the student a feeling of anonymity in answering. Their friends by their side may not even know their chosen answers. This may also lead to a feeling of self-confidence and more willingness to contribute to giving feedback during class, particularly for those who have less confidence in speaking up or participating in classes. More importantly this feedback gives detailed responses to the teacher and statistical feedback on questions posed which helps the teacher gauge how the students perform at problem-solving and in grappling with the new themes presented during class. This feedback can be used to further develop problem solving or get students to discuss between themselves why these answers were or were not chosen. In some scenarios, students may be askes to discuss in pairs why their answer was chosen and then asked to respond a second time, before the correct answer is revealed. This can lead to an improvement in responses. It is known as peer instruction and is described by (Bruff; 2009) and further referred to in figure 3.1.

The types of questions used need not necessarily be restricted to multiple-choice questions. They may also include: 1. Recall questions (which can be used to recall facts, concepts or techniques), 2. Conceptual understanding questions, 3. Application questions (where students apply their knowledge to particular scenarios), 4. Critical thinking questions (where students can analyze relationships between multiple concepts), 5. Monitoring questions (on course design, structure and working dynamics) and many others listed on the website: http://cft.vanderbilt.edu/teaching-guides/technology/clickers/.

Molly Morris, an Associate Professor at Ohio University believes that her students get a lot more out of her class when she uses clickers (see video link: http://www.citl.ohiou.edu/quickstarts/clickers/stub.html). Professor Eric Mazur from Harvard University claims he would not revert to another teaching style after adopting clickers in his physics class.

Cons

Leslie Madsen Brooks, a pedagogic specialist from California speculates that there may be some drawbacks with the use of clickers. She also men-

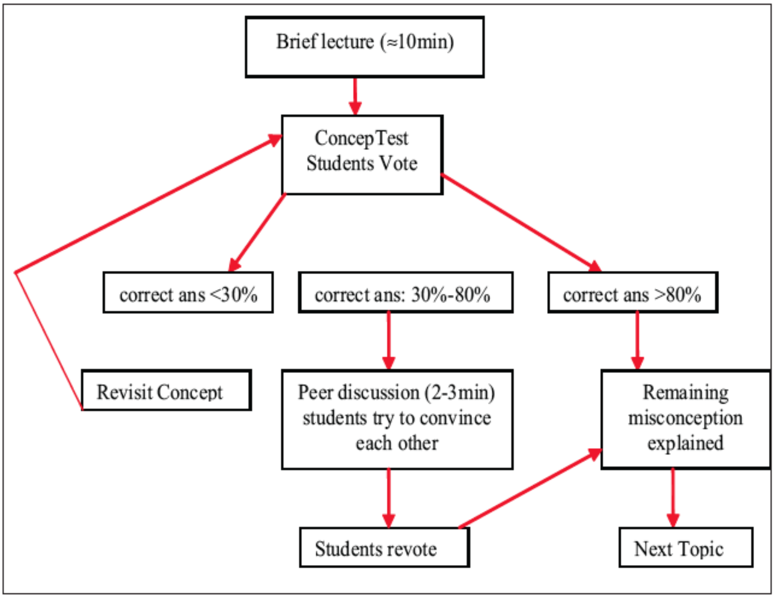


Fig. 3.1. A peer instruction implementation algorithm (From: Lasry (2008)).

tions that there is a price to pay for such technology. Whether this becomes a cost for the student or the University is something that has to be ascertained by the university curriculum. Bugeja (Retrieved December 8 2010) reported that a student advisory committee was against clickers as students deliberately were slowing down the class by selecting incorrect answers. There is also the potential for students to answer on other students' clickers.

It can also be considered that the impact of the clicker tool relies greatly on the teacher's ability to formulate appropriate questions. It also requires the ability of the teacher to interact with the students and their responses to generate the most value from the tool. In some cases, training of teachers in the use of the product would be recommended. Not all teachers will be open to adapt to such new tools for varying reasons. Added workload or a lack of willingness to change their teaching style may contribute to this. Simply launching a new tool within a curriculum does not necessarily improve teaching and student learning. It does require teacher training and instruction on how best to utilize the technology.

Flash cards

Pros

There appears to be little pedagogical difference between flash cards and clickers, provided the questions are applied in the same way. These tools allow for interactive questioning, asking multiple-choice questions etc. They improve interaction between all students and the teacher and may stimulate learning by the students.

Cons

When compared with clickers, one issue arises: that votes can only be visualized by the teacher and the answers can then only be approximated and not accurately calculated. There is also the concern that students can look around the room and see the answers being displayed which may make them doubt their own answer and change to fit the majority of answers being displayed. There is also less anonymity with flash cards than clickers, as individuals can be identified for displaying either the right or wrong answer. The lack of anonymity may be a concern for some students. Neither can the teacher track the response record from students over time, as is the case with some clicker software programs.

Quizzes

Pros

These are good tools for helping students to engage in a lecture. It improves their listening ability and concentration. Quizzes are useful if feedback is given either at the end of class or later in follow-up classes. They may also be useful for summarizing the main points or concepts in the class and placing focus on those concepts that are potentially more important than others. They also induce “active” participation of students in the lecture, and this may be important in their attitude towards lectures and improve their motivation.

Cons

Quizzes may not necessarily improve interactive participation between teacher and students if they are not applied properly. It may also distract the student from listening to other key concepts if he or she is mostly focused on the quiz material. Quizzes are not so useful if feedback is not given, as the students become unclear whether their answers are right or wrong. Quizzes need to be designed well if they are to function well. Too much information can overload and distract the student.

Implementation of novel interactive tools in large class sizes

In my own classes, I applied both flash card questions and quizzes simultaneously to a large lecture hall containing approximately 180 students on two separate occasions. The flash cards used were of two colours, orange and blue, thereby allowing only one choice of two alternative answers. These cards were distributed at the beginning of the class along with the quizzes.

The aim of the flash cards was to stimulate thinking and motivation and participation of the students and to ascertain how much they were obtaining from the lectures. Three flash card questions designed as "True" or "False" were posed during a 50 minute lecture and followed directly after a particular topic. The students were allowed to talk in pairs for one minute before responding and then flash their chosen colour card. The answer was then revealed and feedback given directly. An example of a flash card question can be viewed at the end of this chapter. Some questions in particularly worked better than others. The questions that did not work well, were those that elicited an almost 100% correct response (i.e., they appeared to be too easy). Some questions worked much better and gave more mixed results, which could be followed up in going through the concept again briefly. At the end of the second lecture, students were asked to use their flash cards to reveal whether they thought that this tool helped them to acquire the key points of the lecture. They unanimously voted True, which was very encouraging.

The aim of the quiz was more for motivational participation by the students. In this case, it was necessary for the students to determine three or four answers, which were mentioned during the PowerPoint presentation lecture and were required to fill in the gaps needed. The responses were then presented at the end of the lecture and the students were allowed to keep the information, which was on clear anatomical differences between the different animals that were discussed, as good preparatory material for the exam. A final flash card question asked whether the students found that the quiz helped to show fundamental anatomical differences between different animals and they all agreed. There were a few selected cards that did not show this, which might suggest that a refinement of the complexity of the quiz could be performed.

Feasibility of application of novel interactive tools

In the case of clickers, if the university decides to invest in this teaching tool, it is probably worth setying up classroom pilot tests using clickers from different vendors. There are a growing number of different clicker devices available with a variety of functions and practicalities and it is useful to test these in advance to find the right one, not only by price but also by their functionality and applicability to the course(s) being taught. One useful suggestion could be that the students pay the full price of a clicker, and the campus bookstore pays 50% to buy back the device. It is also a considerable advantage to have a multichannel device, so that nearby classrooms, which may also be using the device, are not affected by the same channel being used. It may also be an advantage if the teacher has the possibility to track answers made by individual students which gives them the ability to track the progress of students during the course and to make changes during the term to match the progress. Ultimately these decisions are made according to the curriculum and this needs to be made to an educated decision. The teachers need to be informed of the considered values of the clicker and the warrant for its introduction into lectures. It may be worth beginning with flash cards, in this case, to gain the students' and teachers' appreciation of interactive teaching with large class sizes before such decisions are made.

Flash cards and quizzes are easily implemented into teaching and certainly do not come at any cost to the institution. It is more up to the teacher to take upon the decision to bring in interactive teaching into his or her classes. Spreading the word through colleagues or introducing fellow teachers and colleagues to one's own classes may open up the discussion and potential spread of such interactive tools.

Quizzes need to be designed well in order to function well. They need to be relatively short and precise and focus on important concepts and themes in the lecture material. Careful consideration of the types of questions posed in quizzes is also important. Multiple-choice questions work well, as do short one-word or short-phrase responses. The key is not to distract the student from the lecture, and provide time during the lecture for the student to be able to respond. Getting interactive responses from the students could be performed in combination with flash cards to get immediate feedback on the answers provided.

Reflections on use of novel interactive tools

“Each instructor’s choices regarding how to use these systems depend on his or her teaching goals and context. A type of question or a structure for a classroom activity that uses clickers might work well for one instructor, but not as well for another instructor teaching a different kind of course in a different discipline to different students”. (Bruff; 2009, p. 13)

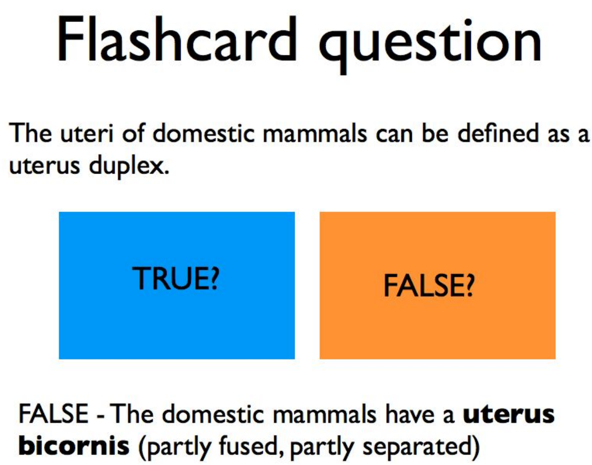
Therefore, it is important that the use of the clickers remains flexible, but still obtains maximal output from the students, that is, improved learning.

In an article written by (Lasry; 2008), a Physics professor from John Abbott College in Montreal, Canada, summarizes that from a teaching perspective, there are significant advantages in clickers compared with flash cards, as they give precise feedback and store students’ responses. However, from a learning perspective, there are no significant advantages for the students in using clickers compared with flash cards. His concluding sentence is “The pedagogy is not the technology by itself”.

The benefits of both clickers and flash cards definitely appear to outweigh their disadvantages. I think, from an economical perspective, it may be worth beginning with flash cards before convincing the teaching advisory boards to invest in clickers. If economy is not an issue, then they should seriously be considered. Given the positive feedback from lecturers and professors using clickers in the United States, it seems that there is more to gain than to lose in applying them in the teaching environment.

In retrospect on my own application of flash cards and quizzes, I did note an advantage in using them in large lectures. The students did appear engaged and responded well to both tools. Some members of the class even came down to me afterwards with some positive words of encouragement on the use of flash cards and quizzes. However, there are ways of adapting and improving the use of them in class. Next time in my own class, I would add one or two additional colour options for the flash cards, giving the students more options and more opportunity to reflect on right and wrong answers. A 50/50 scenario with two cards could be a little too limiting. In addition, I think the quiz could be refined so that less information is presented and there is more discussion afterwards of the answers. Further quizzes could be designed which also pick out main concepts from the lecture. Gaining further feedback on these tools from the students is also vital to ensure that they benefit from them.

A Example of a flash card question given in lecture 1



4

How to enhance student learning by improving the lecture format

Brian Møller Andersen

Niels Bohr Institute, SCIENCE, University of Copenhagen

Introduction

During Blok 2 2010-11 I taught the graduate physics class “Condensed Matter Theory I” at the Niels Bohr Institute, University of Copenhagen. The course has been running for a number of years and the intended learning outcomes (ILOs) and the teaching and learning activities (TLAs) are, to my mind, well aligned with the exam (Biggs & Tang; 2007). The ILOs clearly state what the students are expected to be able to do after completing the class and the exam tests this. During the course the students (in groups or individually) have to complete and hand in four written assignments. They receive formative feedback (Biggs & Tang; 2007). The exam is constructed as a fifth written assignment, which they have 24 hours to complete.

Inspired by the KNUD programme, our pre-project (“*How does the lecture format influence student learning?*”), and Mazur’s (1997) ideas about the didactic game of peer instruction, I became motivated to try new methods to make the lecture format more interactive with the purpose of activating the students and thereby enhance their learning outcome during the lectures. Some previous inspirational KNUD projects on changes in the lecture format have also served as inspiration for this project (Schneider; 2007; Xella; 2009). I was solely responsible for the planning of the class as well as the teaching, which gave some advantages with flexibility to intertwine lectures and exercise classes. I attempted to “measure” the learning outcome by anonymous questionnaires about the content of the lecture immediately after the sessions and also by observation of the student activity level. Additionally, I gave the students a questionnaire at the end of the course about their views on the different activation activities used throughout the course.

The potential problem with lectures

What *is* the problem? Depending on the particular course, the particular lecturer, and the students there may not be a problem. But the aim is clear; to increase the learning outcome during the time the teacher and the students spend together. Traditional lectures are often hampered by an important problem, namely the misconception that student learning equals attentive listening. According to Mazur, we want to avoid the situation where a lecture becomes “a process whereby the lecture notes of the instructor get transferred to the notebooks of the students without passing through the brain of either” (Mazur; 2009). Even with highly motivated students as in the present specialized course with just 20-25 students, the level of concentration drops significantly after approximately 15-20 minutes (see, e.g., the excellent Chapter 2 of Forsvarskommandoen (1989)). A 45 minute lecture with a monologue by the instructor introducing highly technical concepts comes with a large risk of 1) loosing a large fraction of the students, 2) de-motivating a large fraction of the students, and 3) simply wasting everyone’s time because the students are not susceptible to learn any more.

After having given some of these tour-de-force lectures myself in the past, the blank glare in the eyes of the students remaining awake clearly signifies that the learning outcome could be improved by changing the lecture format into a more interactive style. The philosophy is simple: you learn by doing, by making mistakes, and by learning how to undo these mistakes. According to a worldwide study we know that the learning outcome nearly triples by using an interactive teaching style centred on student involvement (Fagan et al.; 2002; *Peer Instruction: From Harvard to Community College*; n.d.). It is exactly this fact that motivated the present study. Is it still true that more activation of students during the lectures increases the learning outcome in a small and rather technical course of physics graduate students?

Improving the format of lectures

Personally, I very much prefer a problem-based learning (PBL) style (Biggs & Tang; 2007). However, the present course is very tool-oriented and the students are constantly introduced to new rather abstract concepts. For this reason, I had trouble using PBL more than sporadically to illustrate some problem (which was unsolvable for the students) and thereby motivate the introduction of new methods. In addition, most of the students were actually very motivated already since they had specifically chosen this class because of their interest in the subject. Instead, I chose to introduce the following items into the lectures in order to enhance student activity (and thereby, hopefully, their learning):

1. Lectures and problem sessions were merged in order to shorten the lectures in the 20 minute sessions followed by individual or group work on a problem related to the past 20 minutes of lecturing.
2. Students were grouped together to discuss their solutions and help each other to reach consensus on the problem.
3. Depending on the specific problem, some groups presented their results followed by group discussions.
4. Students took turns to prepare a 10-15 minute part of the lecture (peer-learning).
5. During lectures I was very conscious of the need to ask the students questions regularly. Depending on the question or "active thinking activity" (ATA), they were supposed to answer right away, or briefly consider and discuss the question before proceeding.
6. Whenever suitable I introduced research papers and presented visual computer simulations to put another perspective on the material at hand.

Other ideas of student-activating TLAs can be found in Biggs and Tang (2007).

Results

In the beginning of the course, the students were handed a short questionnaire about their exposure to various lecture formats and their general preferences in this matter (Appendix A). The first noteworthy result was that on average 94% of the lectures that the students had attended were of the "traditional" monologue lecture format without student participation. This shows that this style is still by far the dominant teaching format at most universities. Half of the students claim to accept this format (although they have not been exposed to other lecturing formats) whereas the other half find it problematic due to minimal personal participation. The students estimate that they lose concentration after approximately 15 minutes. The majority (90%) of the students prefer group work to solve problems and enhance their learning by peer instruction. They have concerns, however, about wasting time if the group is too large, and also many of them stress the importance of the participants in each group being on an equal level.

In order to measure the effects of introducing some of the above six items into the teaching, I decided to use two lectures in the old-fashioned style consisting of teacher-monologue interrupted by just a few questions (by the teacher or the students) as a reference point. After these 2×45 minute sessions, we had 2×45 minutes of problem sessions where the students worked individually on solving a number of problems related partly to the material covered in the lectures on the same day, and partly to a previous lecture. The solutions were discussed by the class afterwards. At the end of the 4×45 minutes, I gave the students a questionnaire about the main items covered on that particular day. The questionnaire consists of eight questions, four testing their ability to repeat an important result, and another four testing their deeper understanding of the newly introduced concepts (see Appendix B for an example). The former (latter) is referred to as a "superficial" ("fundamental") question. Of course, I realize that these questions do not properly test the declarative knowledge of the student, but it does give an idea about their initial learning outcome. In the case of the old-fashioned instructor-monologue lecture format, the results of the questionnaire are seen in the histogram plot (Fig. 4.1).

The y-axis shows the percentage of correct answers to the superficial (blue bar) and fundamental (red bar) questions. I performed this kind of test after two lectures, referred to as lecture 1 and lecture 2, which had eleven and fourteen participating students, respectively. Evidently the scores are disappointingly low. Personally, I was rather surprised to see these low scores. It does agree with the students' own feedback, however, that they lose their concentration after 15 minutes. This means a rough estimate of one-third (half an hour) essential "learning time" and two-thirds (one hour) wasted time during lectures. Although it is not completely clear, it seems that the exercise classes following the 2×45 minute lectures did not play a key role in changing the learning outcome of the session on these two days. This makes sense since the majority of the students did not learn the material during the proceeding 2×45 minute of lecturing. How then were they supposed to solve the related problems?

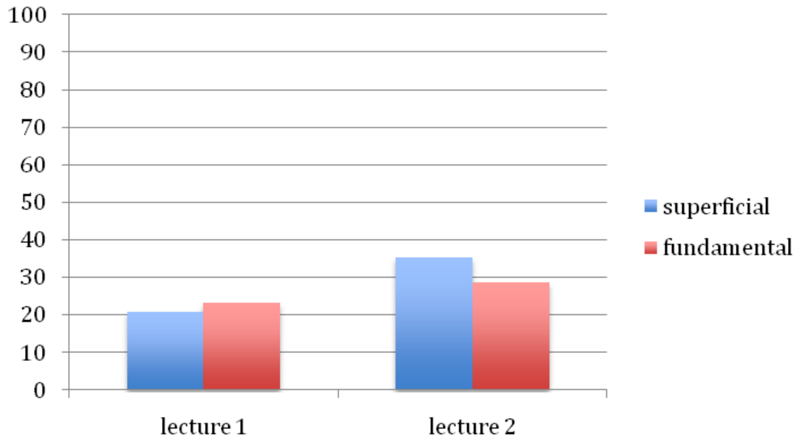


Fig. 4.1. Histogram showing percentage of correct answers to superficial (blue bar) and fundamental (red bar) questions for two different lectures of the traditional monologue lecture format.

Two questionnaires similar to the ones given after the non-student-centred lecture format discussed above, were presented to the students after 4×45 minutes with intertwined lectures and exercise classes (see e.g. Appendix C). In addition, several of the six items outlined above were introduced into these sessions. The lecture parts never exceeded more than 15-20 minutes and I took care to ask several questions during these lecture stretches. The results of the questionnaire are seen in the histogram plot (Fig. 4.2).

For these results lecture 1 and lecture 2 consisted of thirteen and eighteen students, respectively. Evidently the percentage of correct answers has dramatically increased and the learning outcome seems to have significantly improved, by a factor of three! Similar to the results from the old-fashioned monologue lecture format, there is no noticeable difference between the superficial and fundamental questions; they have both been enhanced by roughly the same amount. It is peculiar that this study finds the same enhancement in the learning outcome by a factor of three similar to the comprehensive survey reported in Fagan et al. (2002) and *Peer Instruction: From Harvard to Community College* (n.d.).

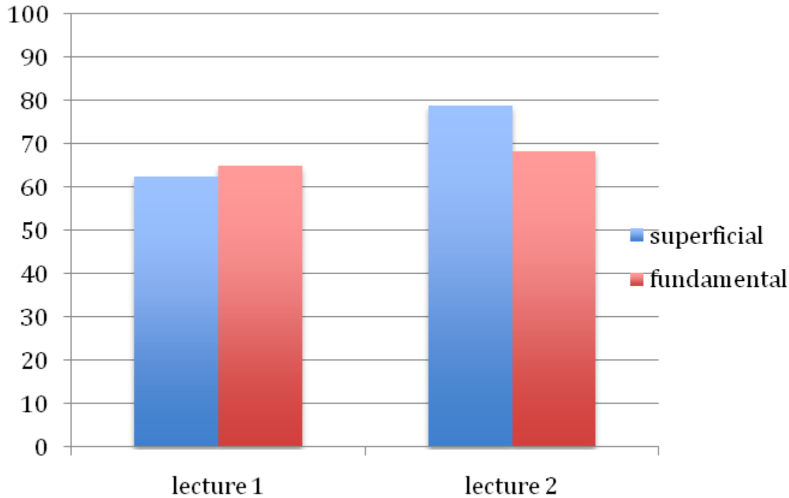


Fig. 4.2. Histogram showing percentage of correct answers to superficial (blue bar) and fundamental (red bar) questions for two different lectures containing the six items outlined in the above section “Improving the format of lectures”.

Discussion

It is remarkable how the simple tests performed during this course have confirmed the superiority of the student-centred teaching format. Of course, one can question the (large) statistical uncertainties in this survey, and one might discuss the particular questions asked in the questionnaires. Nevertheless, I think the trend is very clear; the learning outcome *is* enhanced significantly by continuously activating the students, and keeping the “traditional” lecture stretches below 20 minutes.

Another less measurable difference between the two lecture formats investigated in this project is the overall atmosphere in the classroom. I find that student-centred activities naturally give rise to a positive learning environment. This is largely because such activities “break the ice” and the students quickly become used to doing something or discussing something with their peers during the lectures. Once this kind of environment is established, new questions are naturally generated and the barrier that would often exist to asking the instructor or peers has already been broken down.

As an additional spin-off, the sessions tend to be a lot more interesting for the teacher as well.

Halfway through the course, the students were given a short questionnaire about the lecture format and their estimated workload for this course. This questionnaire was intended mainly to correct the pace of the lectures or the exercises. For the present study, it is interesting that *all* (except one) found the pace of the lectures satisfactory. This was irrespective of whether I used the old-fashioned lecture style with minimal student involvement or the activated-student lecture format. The reason that students did not complain about the pace being too fast during the long 2x45 minutes monologue lecture is probably that the pace was appropriate, but that they simply got tired, lost their concentration, and the material presented just did not register. At this point, halfway through the course, a small (but sizable) fraction of 15-20% of the students "complained" that they missed the standard format of 2x45 minute lectures followed by 2×45 minute exercise classes.

The opinion of the students was followed up at the end of the course by a questionnaire with explicit questions about their preference for the lecture format (Appendix D): 80% of the students preferred the "new" lecture format for the following main reasons:

- Easier to stay focussed in shorter lecture stretches.
- Exercises came at opportune time.
- Activation by questions and peer discussions helped pinpoint which issues are not properly understood.

On the other hand, 20% of the students preferred the "old" lecture format but half of these still prefer lectures with questions and good discussions whereas the other half prefer a 2×45 minute monologue lecture. They question what they can learn from peers and point out a problem with intertwined lecture and problem sessions: wasted time for the good students. Regarding the former, I simply disagree. Even if they cannot learn much from their peers, they can still learn a lot from discussion with them and explaining the physics to them. Regarding the latter, I agree that there can be a potential problem in the sense that very good students end up waiting for the rest to catch up before the next part of the lecture can proceed. There need to be additional problems or follow-up questions to challenge these students.

Conclusions

The learning outcome can be significantly enhanced by planning student-centred and student-activated lectures. This is true even in small graduate classes where the students are supposed to learn how to work with new theoretical tools, i.e., in rather technical courses. The present study showed that the learning outcome is enhanced by a factor of (approximately) three by this method. This increase is valid both for the deeper understanding as well as the ability to use and remember newly acquired tools and results. While most of the students prefer the "new" lecture format this opinion is not unanimous. A minority of the students preferred the old-fashioned style with much less student-instructor interactions during the traditional 2x45 minute lectures. I speculate that this may be related to the fact that it is easier to remain inactive/passive, whereas continuing student challenges during lectures is more demanding for students. When lectures and problem sessions are intertwined special care must be paid to the stronger students to that they are challenged throughout the whole session.

A Student questionnaire on "How to enhance student learning by improvement of the lecture format"

Below, the phrase "traditional lecture format" refers to non-interactive lecturing where the teacher alone presents the material on the board/computer and asks only very few questions from the audience.

1. During your previous courses what percentage (roughly) have been by the traditional lecture format?
2. Do you like that way of learning? Why/why not?
3. How much of a 45 minute class would your brain tend to go on standby? What would it take to avoid this "zoom-out" state?
4. What other format have you been exposed to in lectures? Did any of them enhance your learning?
5. Do you find that group work makes you learn better? Why/why not?
6. Other comments/remarks:

B Small set of questions for today's lecture: 4 December, 2010

1. What is the meaning of A(τ) in the imaginary time formalism?
2. What is the definition of U(β,0) (words or equation)? What expression for U did we derive today?
3. We used U(β,0) to derive an explicit expression for $-\langle T\tau\ (A(\tau)B(\tau'))\rangle$. What was this expression?
4. What are iωn for fermions?
5. What is the free Green's function in terms of Matsubara frequencies?
6. What reasons are there for introducing the imaginary time formalism.
7. Why did we have to learn how to perform sums of Matsubara frequencies?
8. How is the imaginary time formalism related to what we have studied earlier?

C Small set of questions for today's lecture: 7 December, 2010

1. Why is Wick's theorem important for arriving at the Feynman diagrams?
2. What is the Master Equation for the full Green's function G(b,a) that we derived today?
3. How would you draw an expression containing W11'W22'G0(b,1')G0(1,a)G0(1',1)G0(2,2')G0(2',2)?
4. Is it possible to write the full Green's function G(b,a) in terms of only connected diagrams? Why/why not?
5. How would you draw ⟨U(β,0)⟩0 to 1. order?
6. What is a Feynman loop and what is the importance of the number of these beasts for a given diagram?
7. Our formalism is for imaginary time. But where exactly does temperature T enter a given Feynman diagram?
8. How many of the 6 Feynman Rules do you remember?

D Small set of questions to lecture format: 4 January, 2011

During this course we have had different formats for the lectures. This questionnaire asks your opinion about these.

1. Which do you prefer: (A) Standard 2×45 minute lectures followed by 2×45 minute problem session, or (B) mixed lectures and problem sessions with shorter stretches of lecturing by the teacher?
2. What are your reasons for choosing (A) or (B)?
3. Do you think you learn more/better with format (A) or (B), or does it not matter.
4. What is your preferred lecture format?
5. Often during the lectures we have had a student present a small section from the book. Did you like this? Why/why not?
6. During some lectures the teacher has asked many question to the audience. Do these help you? Why/why not?
7. Do you have any suggestions on how our 2×4 weekly hours together could have increased your learning outcome?

5

Designing a Course in Agribusiness Economics that Encourages Active Student Participation

Arne Henningsen

Institute of Food and Resource Economics, LIFE, University of Copenhagen

"Learning takes place through the active behavior of the student"

Ralph W. Tyler (1949)

Introduction

This report describes how I designed and taught the MSc course Agribusiness Economics II"[1] and evaluates the various teaching methods and measures that I used.

The course Agribusiness Economics II gives 7.5 ECTS points and should have a total workload of 206 hours. Eight weeks are designated for teaching and one week is for the exam. Classes can take up to 12 hours per week, and the lecturer is free to allocate different teaching methods (e.g. lectures, exercises, group work). I was the only teacher of this course, although I received some assistance from a PhD student, for example, in the practical exercises.

As the title of the course is rather vague and my research interests differ considerably from those of the previous teacher, I changed the content of

[1] The course is taught at the Faculty of Life Sciences of the University of Copenhagen and has the course number 290050. It coincides with the second part of the Thematic Course: Agribusiness Economics (course number 290062), which is compulsory for students who follow the MSc programme in Agricultural Economics and choose the specialization "Agribusiness and Food Economics". Usually, a few students from other specializations or other MSc programmes take this course as an elective course.

the course so that it fitted better with my research interests. When I selected the content of the course, I considered four criteria: (i) the content should be comprised of topics which are generally considered to be important aspects of a curriculum in applied (agricultural and agribusiness) economics; (ii) the content should be covered by the intended learning outcomes (ILOs) of the study programme; (iii) the content should not be covered by any other course at our faculty, and, (iv) the content should be related to my research areas in order to facilitate stimulating research-based teaching. Based on these criteria, I chose two topics: (i) reducing price risk by using futures markets (two weeks) and (ii) applied econometric production analysis (six weeks). In both parts of the course, I focused on agribusiness firms and concentrated on practical applications, as I was sure that most students would benefit (e.g. in their future jobs) from practical skills and competences more than from theoretical knowledge.

This year, fifteen students participated in the course: five were Danish, three came from other European countries, five came from Sub-Saharan Africa, and two from Asia. As these students came from different universities and had degrees in different subject areas, I expected that their prior knowledge in the subject areas relevant for this course (e.g. microeconomic production economics, econometrics, statistics, mathematics) would be very heterogeneous.

As students learn best when they are active (see e.g. Tyler; 1949; Biggs & Tang; 2007, p. 21), I designed the course in a way that would "activate" the students. The general approach to teaching was "problem-based learning" and I tried out various teaching methods that are supposed to activate students. Furthermore, the intended learning outcomes (ILOs), teaching methods, and the exam should be constructively aligned.

In the following section, I will describe the most important teaching methods that I used during the course, present my reasons for choosing them, and evaluate their success. In the third section, I will present an overall assessment of the course. The fourth and last section concludes.

Teaching methods

Problem-based learning and the use of textbooks

The general teaching method that I used on the course was "problem-based learning". Hence, I did not go through a textbook page by page, rather the problem that had to be solved determined which part of the theory and hence, which pages of the textbook were relevant. As the students will probably have to find the relevant information and theories on their own at a later date (e.g. in their job or when writing their thesis), I told them that they should practise these skills by finding the relevant information themselves. I suggested a few textbooks and left it to them to select the one they liked the most. This also meant that the students had to reflect on the kind of information they needed from the literature, which should further increase their learning. To facilitate this, I provided a lecture schedule on the e-learning platform for the course[2] where I listed the topics for each class so that the students could easily find these keywords in the index of their textbook. However, some students felt uncomfortable with this and a few of them complained and said that they would rather have traditional lectures, where the teacher goes through a textbook page by page. As a compromise, I added the numbers of the relevant pages in the primary textbook (Chambers; 1988) to each topic in the lecture schedule on the e-learning platform so that the students could find the theories which were taught during class even more easily (e.g. if they did not attend the class). Furthermore, the library only provides a very limited number of copies of the suggested textbooks so that most of the students had to buy their own. As they did not want to buy more than one textbook, or take the risk of spending money on the "wrong" textbook, all the students obtained the primary textbook. Of course, this somewhat contradicts the intended learning outcome, but I could understand that the students did not want to gamble with their money and I thought that it did not make sense to overstrain the students, who had not experienced problem-based teaching before, with a change in the teaching method that was too substantial and abrupt.

However, in general, I think that the problem-based learning approach was very successful: the students were usually very motivated and active and were rarely idle during classes, whilst most of them generally took a "deep" approach to learning. Furthermore, most of them liked this way of teaching very much. When I teach my next course, I will first check the availability of textbooks in the library and explore how familiar the students are with the problem-based learning method and then decide whether I should refer to several textbooks or just focus on a single textbook. Finally, as problem-based learning requires the students to think independently and

[2] The University of Copenhagen uses the e-learning system "its learning" (http://www.itslearning.eu/) and calls it "Absalon".

to apply their theoretical knowledge, it is more demanding for students than traditional lectures. Hence, one should not expect that *all* the students will be happy with this teaching method.

Pre-assessment and catch-up sessions

As I expected that the prior knowledge of the students would be very heterogeneous, I conducted a pre-assessment of the students. This pre-assessment showed that their prior knowledge was less heterogeneous than I had expected, but it was generally rather low. Almost all the students had significant gaps in their knowledge about the basic concepts of production economics (e.g. production function, marginal product) and basic calculus (e.g. simple operations with fractions). These findings were confirmed in the problem-based exercises when the students had difficulty solving the exercises because of their lack of knowledge in basic production economics and basic calculus. Therefore, I offered a few short catch-up sessions in basic production economics and basic calculus during the first two weeks. These sessions were either at the beginning or at the end of a class so that students could easily skip the sessions. I think that these catch-up sessions brought the students' knowledge up to standard so that they could solve the exercises, although a few students complained that basic topics should not be taught on an MSc course. Hence, in the future I will communicate more clearly to the students that these catch-up sessions are voluntary. Alternatively, I might even skip the catch-up sessions and suggest books to the students that they can use to fill the gaps in their knowledge, i.e., also allow the students to use problem-based learning to fill their knowledge gaps.

Long classes

A maximum of twelve hours per week can be used to teach this type of MSc course, although most teachers use nine or less hours. However, I decided to use nearly all twelve hours per week for teaching, which gave me sufficient time for extensive practical exercises, thorough repetition, and some extra sessions such as catch-ups, quizzes, and interactive preparation of lists of definitions (see below). I consider this to be an important advantage, as usually only a few students do voluntary homework exercises and repeat at home. As weaker students often do not benefit from individual homework (Wiere & Gängler; 2008), these classroom repetitions should be particularly supportive of these students.

I think that using the maximum available time was a good decision, as the practical exercises and the repetition sessions definitely supported the students' learning, particularly the learning outcomes of the weaker students. Furthermore, the students liked the extra sessions (e.g. quizzes) very much and only a very few mentioned that the classes were too long.

Hands-on learning

My primary aim for this course was that the students should learn practical applications in the areas of futures markets and econometric production analysis, as most students will benefit much more from these skills and competences than from pure theoretical knowledge. As practical skills can be only learned by practical applications, a large proportion of the classes was devoted to practical exercises. For instance, the students had to protect a (virtual) firm from losses due to price changes by trading (realistic) futures contracts on a virtual futures trading platform[3], or they had to find out the optimal firm size by using microeconomic production theory, data of individual firms, and econometric software.

Given that I used the problem-based learning approach and that we focused on practical applications, the students only learned those parts of the theory that were relevant for answering the addressed questions (problems). Of course, I selected and formulated the questions (problems) so that the most important parts of the theory were covered. When conducting the practical applications, most students really "internalized" the theoretical background. Hence, I did not consider it problematic that the course did not cover a wider range of theories as I consider the "deep learning" of a limited amount of theory to be much more desirable than the "surface learning" of a much larger amount of theory that the students cannot apply and quickly forget after the exam.

While most students appreciated this hands-on approach very much, a few of them attached little value to the practical skills and competences. These students complained that they learned too little (theory) on the course. For instance, a part of the theory that they used for their

[3] This futures trading game is organized once a year by the Commodity Futures Trading Group of the University of Kiel (http://www.bvwtm.uni-kiel.de/en_index.html). Many different futures contracts can be traded in the game. The contracts have exactly the same specification as real futures contracts and prices are also taken from the real futures contracts.

practical applications had already been taught on the BSc course "Produktionsøkonomi" (production economics). However, the students had not learned how to apply this theory for econometric production analysis. As some students did not assign value to the learning of these skills, they complained that they did not learn *anything* during the lectures[4]. However, while at the beginning of the course none of the students could conduct the empirical analyses, let alone the interpretation of the results, most of them had become very skilled at this by the end. Furthermore, most students considered the academic level of the course to be suitable (see section "Overall evaluation of the Course" and figure 5.1(b)). Therefore, I will continue to focus on the application of economic theory rather than teach pure theoretical knowledge in my future courses.

Dialogue teaching

During the actual teaching, I used the method "dialogue teaching". I asked questions to guide the students so that they found the answers and solved the problems themselves rather than telling them the solutions straightaway. This should encourage students to really think about the topic and hence, support the deep approach to learning (see e.g. Biggs & Tang; 2007, p. 22ff). Furthermore, students should become aware that they can find answers and solutions on their own, which should increase their confidence in their abilities. Finally, I think that this way of teaching reduces the likelihood that students will be idle or drift away with their thoughts during sessions, as I engage them in the "dialogue".

To facilitate communication with the students, I learned the students' names very quickly (which was actually not very difficult with just 15 students). If no student volunteered to answer, or only those who had already contributed a lot, I encouraged individual students to share their thoughts with the others. However, two students told me that they did not like to be asked questions unless they raised their hand; I respected their wish.

If no student knew the answer to my question right away, I asked the students to discuss the question with their neighbours for two minutes and I repeated the question to be sure that all the students knew exactly what

[4] Although these students claimed that they had already learned this theory, they were usually unable to recall, let alone apply it. In fact, the students who had taken the course "Produktionsøkonomi" were on average no better at solving the theoretical exercises in the written exam than the students who obtained their previous degree from another university.

they were supposed to discuss. This really "activated" the students and they often found the answer after discussion, or they at least got much closer to the solution. This was a nice psychological break for the students, and some were even able to discuss in their native languages (Danish and Swahili), whilst it also gave the teacher a welcome short break.

During these lectures, I visualized all important statements on the blackboard and I did not project slides onto the wall, as dialogue teaching is driven by the students and I could more easily follow the students' way of thinking on the blackboard. In contrast, slides cannot be adjusted in real-time which means that I would either have to force the students to go "my way" or a situation might arise whereby the sequence of concepts presented on the slides might deviate from the development of discussion during the lecture – both procedures are very undesirable.

I am very satisfied with this way of teaching, as the students in general were actively thinking and searching for a solution and they were not afraid of giving the wrong answer. Furthermore, most students liked this way of teaching very much. For example, one student (No. 4) wrote in the course evaluation "I like his way of teaching, because somehow everybody gets to understand" and a further student (No. 8) wrote "it was never boring".

However, as this teaching method – likewise problem-based learning – is more demanding for students than traditional lectures, one should not expect that *all* students will like it. For instance, one student (No. 9) made the following criticism in the course evaluation: "It seems like he wants us to discover everything on our own" (which is indeed the aim of dialogue teaching). Furthermore, some students preferred to be given the lecture slides. As I understand this request, but I would like to continue using the blackboard in future courses, I plan to take a photo of the blackboard before I clear it and make these images available to the students on the e-learning platform.

Homework assignments and peer assessment

The ILOs of this course stress practical skills and competences in particular. As performing practical applications is the best way to achieve such ILOs, it is important that the students not only practise this during class, but also at home. Therefore, I planned homework assignments for the students, which I wanted to implement in such a way as to achieve the following objectives:

- the students should not do the homework assignments individually, but in groups so that they can learn from each other and learn to discuss and communicate the theories, methods, and results,
- the students should have a strong incentive to prepare their homework assignments thoroughly, because in my experience, many students – and particularly the weaker students – are not very motivated to do voluntary homework assignments and they often do not do them at all,
- students should only receive formative feedback on their homework assignments, because – in contrast to summative feedback – this supports students' learning (Butler; 1988; Black & Wiliam; 1998),
- students should give and receive feedback on each other's homework assignments, as this allows them to learn from each other and to reflect on their own assignments, and
- finally, the grading of the students should not be based on the assessment of group work, as this is prohibited by Danish law.

All these objectives were achieved by the following procedure:

The students were given six homework assignments during the course (one per week, from the second week to the seventh). They were supposed to solve the assignments in groups and upload them to the e-learning platform within one week. Every group was given another group's assignment and was asked to provide formative (peer) feedback to the group that had prepared the assignment (again within one week). After receiving feedback from their peers, the groups were allowed to revise their assignments and to update the version on the e-learning platform. At the end of the course, there was an oral examination, during which the students were supposed to explain ("defend") one of their group's homework assignments. About 30 minutes before the oral exam, the students randomly drew one of the assignments. They received a print-out of the selected assignment, which their group had uploaded to the e-learning platform, so that they could prepare themselves for the exam.

Some students claimed several times that they felt uncomfortable with receiving feedback "only" from fellow students. They urged me to give them the solutions to the homework assignments. However, as providing solutions to exam questions *before* the exam encourages rote learning rather than "deep" learning, I did not provide the solutions and I explained why to the students. However, as a compromise, I went through all the revised versions of the students' homework assignments and gave them brief formative feedback. This procedure still provides a large incentive for the students to carefully prepare and read the peer assessment reports, because they can improve their homework assignments after receiving the peer-feedback, but not after receiving feedback from the teacher. At the same time, the students could feel more relaxed and confident during the oral examination, as they had been told if their assignments had major flaws and they had been given time to figure out the correct solution if necessary. Of course, they also had the opportunity to discuss their solution not only with their fellow students, but also with their teacher.

All the groups submitted all the assignments and the quality of the homework was generally very high. Also, the peer assessment, in general, went very well. Most students found the peer assessment really helpful and most groups significantly improved their assignments after the peer assessment. However, a few students claimed that the peer assessment was a waste of time and one group refused to provide any (useful) feedback to the other groups. The oral examination showed that most students seemed to have actively participated in the preparation of the homework assignments, as they were able to explain exactly what their group had done in the homework assignment. However, a very small minority of students seemed to have been "free-riders" during the preparation of the homework assignments and they were therefore, unable to explain what their group had written. Hence, this seems to justify the prohibition of grading according to group work.

Overall, I think that the procedure for the homework assignments was a successful strategy for supporting the students' learning. Furthermore, the students evaluated the homework assignments very positively in the course evaluation. For instance, one student (No. 1) wrote, "The assignments – good opportunity to reflect on classwork", whilst another student (No. 10) wrote, "The weekly assignment made me reflect on [...] what was being taught in the course", and a further student (No. 13) wrote that "the homework [...] gives room for the students to work together and practise what they learn in class".

Interactive list of definitions

The students urged me several times to give them a list of all the definitions used in the course. As I thought that giving them such a list just would support rote learning, I chose an interactive way of preparing the list. First, I created a "process-oriented document" on the e-learning platform, where the students could add the definition of any relevant term. Then, I wrote the most relevant terms on small pieces of paper. During one class, I distributed these pieces of paper among the students and asked them to add the definitions of these terms to the above-mentioned “process-oriented document”. While the students added these definitions, I went through all finished definitions and either wrote that they were correct or pointed out the things that were either unclear or incorrect. In any case, the student who had added the definition, or any other student, could improve the definition. This went very well and after about 45 minutes, the students already had a sizeable, albeit incomplete, list of definitions. I told the students that they should continue to improve the existing definitions and add new ones at home until the end of the course. I also suggested that they use the document to discuss and comment on each others’ definitions. Furthermore, I promised to look at their definitions every few days and to give feedback on each single definition. However, while the introductory session within the class went very well, only a very few students later revised and added a small number of definitions at home – even though I reminded them to continue the list several times. Hence, it seems that the students found the list of definitions less useful than they initially thought. Therefore, I am unsure whether I will use this teaching method in my future courses.

Quizzes

About once a week, I used a “quiz” for assessing, completing, and reinforcing the students’ learning outcomes regarding the topics taught in the previous lectures. I prepared slides with one multiple-choice question on each. For each question, four possible answers (named “A”, “B”, “C”, and “D”) were given, with only one out of the four answers being correct. Each student got four answer cards with “A”, “B”, “C”, and “D”, respectively, written on them. The answer cards had four different colours, with each colour corresponding to one of the four letters. The colours make it easier and quicker to grasp (for the teacher as well as for the students) which answers have been chosen by the students. For each of the questions, I showed the corresponding slide and read the question and the four possible answers aloud. The students could think about the correct answer for around one minute (depending on the complexity of the question), and then I asked the students to show the answer card, which they thought was correct. I subsequently encouraged the students to discuss the possible answer with one or two fellow students who had shown a different answer card. When I noticed that the discussion among the students had declined considerably, I again asked the students to show the answer card, which they thought was correct to see whether the discussion had increased the number of correct answers. Finally, I revealed the correct answer and – if several students had still got the wrong answer – explained why it was correct and why the other answers were incorrect.

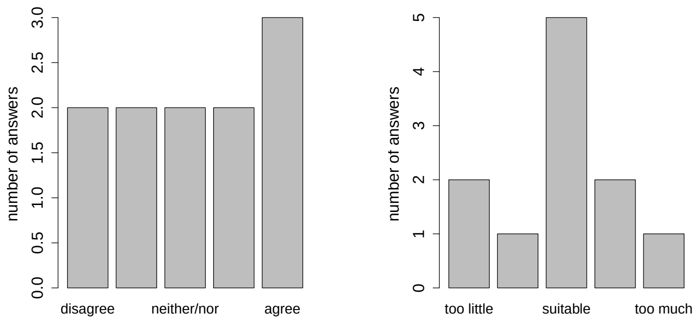
I am generally very satisfied with these quizzes. They provide very helpful feedback on the students' learning progress for the students as well as for the teacher. While usually more than half of the students showed the wrong answer card in the first round, most students showed the correct card after discussing the questions with their fellow students. Hence, it seems that the students who showed the correct answer card in the first round were able to apply their knowledge and convince the others. On the other hand, the students who showed the wrong answer card in the first round, but the correct answer card in the second round, had obviously increased their knowledge. This assumption was also affirmed by the students. For instance, after one of the quizzes, one student told me that he had learned several things during the quiz, although he always showed the correct answer already in the first round. Furthermore, many students mentioned in the course evaluation that they found the quizzes extremely useful and fun.

Overall evaluation of the course

The course evaluation shows considerable disagreement among students about the overall quality of the course. Two students (No. 2 and 9) strongly disliked the course and gave very negative comments. For instance, one of the two students wrote "This part of the course has not worked at all for me and i think that it is a shame", whilst the other wrote, "the course has been crap". A few students urged me several times during the course to teach in a more traditional way. However, as many scientific studies have shown that traditional lectures are a rather inefficient teaching method coupled with the fact that most of the students liked the course as it was, I only granted some of the students' requests (e.g. providing the page numbers in the textbook, additional assessment of the homework assignments by the teacher) whilst I also tried to convince them that problem-based learning has many advantages over traditional lectures.

However, the majority of the students really liked the course as it was taught (Fig. 5.1(a)). These students wrote, e.g. "The course met my objectives" (student No. 1), "all in all I found the course very interesting" (student No. 5), "The topic was relevant to me" (student No. 7), and "I did learn a lot" (student No. 8).

Furthermore, most students considered the academic level of the course to be suitable; only three students considered it to be too low whilst three students thought it was too high (Fig. 5.1(b)).

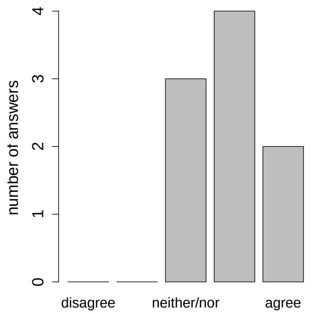


(a) All in all the course was good

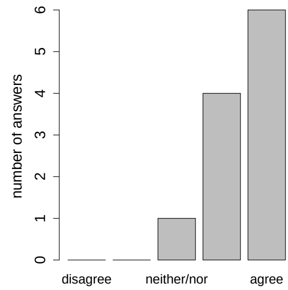
(b) Compared with my own qualifications I found the academic level

Fig. 5.1. Students' overall evaluation of the course and the academic level. Note: "(dis)agree" is an abbreviation for "I very much (dis)agree" and "neither/nor" is an abbreviation for "I neither agree nor disagree". The same is true also for all following figures.

The course evaluation also shows that I was very successful in reaching one of my main objectives for the course; namely the "activation" of the students. For instance, one student (No. 5) wrote that "It was a great experience during this class with this teacher because it was participatory with a lot of assignment and this had a positive effect on my studies. May be it will be a good idea if other teachers can do this too", whilst another student (No. 8) wrote "There was high interaction in the class". The students strongly agreed that the assignments provided room for independent problem-solving (Fig. 5.2(a)) and they almost completely agreed that the course provided room for their active participation (Fig. 5.2(b)).



(a) The project work provided room for independent problem solving



(b) The course provided room for active participation on my part

Fig. 5.2. Students' perception of independent problem solving and active participation

Conclusion

I designed and taught the MSc course Agribusiness Economics II based primarily on problem-based learning. I tried out various teaching methods; most of them were really successful (e.g. quizzes, homework assignments, dialogue teaching, hands-on learning), but a few of them were not optimal. I improved some of the sub-optimal methods during the course (e.g. lecture schedule with page numbers, additional assessment of homework assignments by the teacher) and I plan to further improve some of the methods in my future courses (e.g. referring to only one textbook, effectively utilizing the blackboard and making photos available for the students). Furthermore, I will explore the reasons why some students were dissatisfied with the teaching methods so that I can hopefully reduce the number of dissatisfied students without compromising the essential design of the course. Overall, I gained a lot of experience with modern teaching methods during this course and I hope that sharing my experiences in this report will stimulate readers to try out some of these teaching methods in their courses.

Acknowledgements

The author is grateful to Robert (Bob) Evans, Lars Otto, Géraldine Henningsen, Camilla Østerberg Rump, Lars Ulriksen, and Per Svejstrup Hansen for many helpful hints and valuable suggestions. Furthermore, the author is grateful to the Commodity Futures Trading Group at the University of Kiel (http://www.bvwtm.uni-kiel.de/) for organizing their very realistic commodity futures trading game.

6

Implementation of Teaching Learning Activities during single lectures on a multiple teachers' course

Gitte Erbs

Department of Plant Biology and Biotechnology, LIFE, University of Copenhagen

Introduction

The multidisciplinary approach to teaching in universities involves teachers or scientists from different scientific disciplines. These multiple teacher courses can result in individual teachers only having the opportunity to teach once, or perhaps twice, during a semester. During a multidisciplinary course the students will, most likely, meet as many different forms of teaching as there are teachers. So, what can a teacher do to be sure that the students achieve the learning outcomes intended? Having to give only one or perhaps two lectures, one approach could be to write out the intended learning outcomes (ILOs), for instance, on the blackboard, then the students know what they should be able to do after completion of the lectures.

In general, lectures are very effective for presenting information to the students, but not so effective for student learning. Using Teaching and Learning Activities (TLAs) that address the intended learning outcomes, outstanding and inspiring teaching is possible. Maintaining the students' attention can be hard, especially if there are no breaks or change in activity during a lecture. Instead of sitting passively listening to a lecture for 30 to 60 minutes, incorporation of student activities or short rests will improve the students' learning outcomes, as illustrated in figure 6.1.

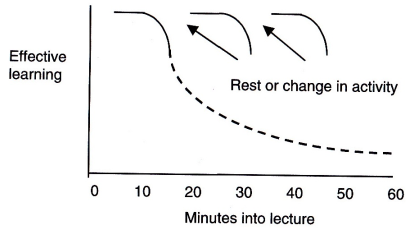


Fig. 6.1. The figure illustrates the effect of rest or change in activity on learning (Biggs & Collis; 1982).

Teaching and learning activities

The course *Mikrobielle Interaktioner* was split up in three subjects: *Interaktioner i forhold til det ydre miljø*, *Interaktion mellem mikroorganismer* and *Interaktion med højere organismer*. I was responsible for half a day of teaching in the last theme and taught innate immunity in plants. I designed two ILO statements for the 35-minute lecture I gave using verbs from the SOLO (Structure of the Observed Learning Outcome) taxonomy (Biggs & Collis; 1982). There are several levels of understanding and the SOLO taxonomy, which is a hierarchy of verbs, can be used to classify the learning outcomes in relation to their complexity. The two ILOs for my lecture were: After this lecture: 1) you will be able to *explain* the term MAMPs and *estimate* its importance in plant innate immunity. 2) You will be able to *analyze* peptidoglycan and muropeptides as MAMPs in plants. Here I used the verbs "explain", "estimate" and "analyze" mainly from the relational level in the qualitative phase. I found the relational level to be suitable for this second-year course.

Instead of lecturing, I decided to engage the students by introducing TLAs, which I felt was received very well by the students, even though it was something quite new for them to try. I used TLAs that included activation of the students. I do not think that the use of TLAs when lecturing is a common way of teaching at LIFE yet, but the students were motivated and participated actively in the activities/discussions. I found the introduction of the TLAs made time fly not only for me as a teacher but also for the students. I incorporated two TLAs, one every 15 minutes. After a short introduction to the theory, the students had their first assignment, a student-to-student talk where they had two minutes to explain in their own words what I had just gone through and come with examples of it. This form of TLA requires that the students participate actively in the lecture, but the idea is also to give the students the opportunity to talk to a fellow student and if there is something they do not understand they can then approach the class saying, "We do not understand...".

After another 15 minutes the level was raised and the students, in small groups, were given four minutes to discuss and reflect on two scientific figures. The points raised during the two TLAs were listed on the blackboard and feedback was given to the students. The incorporation of the TLAs, here in the form of assignments, resulted in a very interactive lecture.

Student evaluations

After my day of teaching, I asked the students for evaluation of my teaching. I made an evaluation sheet with the following three questions:

- Blev læringsmålene opfyldt? (Were the learning objectives met?)
- Hvad var det bedste ved undervisningen? (What was the best thing about the teaching?)
- Hvad kunne gøres bedre? (What could be done better?)

All the students answered the three questions in the evaluation sheet. From this type of evaluation sheet, one can expect as many different answers as there are students. The evaluation sheet covers the whole day, not only the lecture but also the following colloquium. Findings from the evaluation revealed that 100% of the students felt that the ILOs were achieved, that is, they answered "yes" to question one. In addition to this, a majority of the students, 54%, rated the incorporation of the TLAs as the best thing about my teaching. Another 31% of the students rated that handing out a copy of my PowerPoint slides when the lecture started was the best part of my teaching, 15% of these 31% meant that the incorporation of TLAs *and* handing out a copy of my PowerPoint slides as the best part of my teaching (see the illustration in Figure 6.2 for the students' answers to question 2).

There is always room for improvement, and as my last question I asked the students "Are there somethings I should have done differently?". In their feedback, 46% of the students answered that the breaks/preparation time of the following colloquium had been too long, while others (15%) said that it was good to have time for preparation. Overall this is a task that is easy to improve/change in the future, but it also depends on the

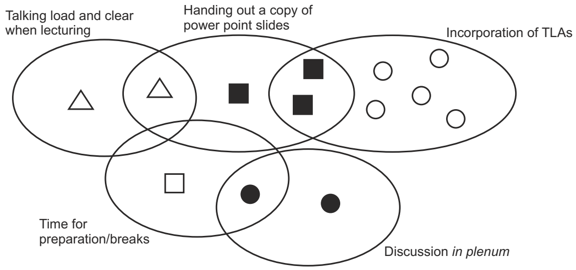


Fig. 6.2. The figure illustrates the distribution of the students' answers to question 2 "What was the best part of my teaching?". The different subsets represent their answers. White circles: incorporation of TLAs. Black squares: handing out a copy of PowerPoint slides. Triangles: speaking loud and clear when lecturing. White squares: time for preparation/breaks. Black circles: discussion in plenum.

participating students; what level are they at in addition to the difficulty of the material being taught. In general, the answers to question 3 were mainly about the following colloquium not the lecture.

Conclusion

In general, the feedback from the students has been very positive, and I find consistency between the students' and my perception of the teaching. From the discussion we had in plenum during the colloquium, I could tell that the students had achieved what I had intended they should learn. They were aware of the definitions we had gone through in the lecture, and they could use them in context as well as being able to go beyond what we had discussed during the more formal part of the teaching.

I do not know how the other teachers on this course teach, or how well their teaching is aligned with what is intended for the students to learn, but this assignment has convinced me that it is possible to make students learn even though you only have a few lectures in a course. It is not a matter of being responsible for a course during a whole semester or only being responsible for a few lectures; it is the way you teach that matters, or I should say, how you make the students learn.

Even though I only had one day of teaching in this course, I tried to align my teaching with what I wanted the students to learn and the final assessment. The student evaluations tell me that it has been possible for me to align my part of the teaching on this multiple teacher course with the ILOs. The final assessment is constructed in a way that will tell us how well the students have achieved the intended learning outcomes. The form of the final assessment is a 24-hour written exam, where the students are given an assignment as well as a paper and have 24 hours to show that they have achieved the learning outcomes for the course/subject. Three different assignments were made, corresponding to the three subjects within the course and the assignments were randomly divided between the students. This means that a third of the students received an exam assignment in the subject *Interaktioner med højere organismer*, this group of students performed very well. The assignment was exactly on the subject plant innate immunity, the subject I, to a large extent, taught. This summative assessment told me that the students had learned what I laid out in my ILOs.

7

Activation and motivation of students in Seed Science and Technology for improved learning using interactive lecturing

Henrik Lütken

Department of Agriculture and Ecology, LIFE, University of Copenhagen

Introduction

In 2010, I taught on the Seed Science and Technology course twice; in October, my teaching was a special edition of the course designed for a group of Egyptian students and scientists (six persons). In December, I taught on the regular version of the course for a mixed group of Danish and foreign students (twenty persons).

Seed Science and Technology is a joint BSc and MSc course, where many teachers are involved. I teach the specific part called: "Maintenance of genetic purity and identity using biotechnology methods to identify gene manipulated crop (GMO) seeds". The time schedule for this part is very strict as it is composed of only three half days in which, besides lectures, a laboratory exercise has to be conducted.

Previously, I had taught the course twice, in 2007 and 2009. My general experience was that the laboratory work motivated the students to a high degree as the students were very active and dedicated during that part, but not so much during the lectures. In 2009, I designed the teaching part myself and one of my goals was to motivate and activate the students more, especially during lectures, as I felt that was needed after teaching according to the course plan that was handed out in 2007. Hence, in 2009, I incorporated a student assignment on GMO legislation in EU which led to a general GMO debate, but still only few students, typically the Danes, participated actively. So I still felt I needed specific tools to motivate the students even more to promote deep learning. After I had taken the theoretical part (KNUD) of *adjunktpædagogikum* (Higher Education Teaching and Teaching Practice Programme), I tried to apply specific pedagogical tools in the 2010 course.

Problem definition

I will try to plan the lecture as an interactive lecture. The students will have access to some background literature and some web pages concerning GMO legislation in EU in advance, to be introduced to the subject and inspired to form an opinion. When the students arrive, I will give them an outline of the day, and afterwards they will be given some small assignments that they will work on in teams. Later, the students will try to provide answers to the given questions and this will then open up for a debate. My intentions are to focus on the basic concepts and to use inspiring examples or case studies known from the media, where the students in pairs rather than groups (to increase the activity of the individual student, as it is more easy to "hide" in a group) will discuss or buzz on small topics and maybe use a quiz or take a vote as activating tools.

My vision is to make the students capable of reflecting on both the application and ethical aspects in relation to GMO seeds and plants.

Will a more interactive lecture form, e.g. group work and small assignments, increase the activity level of the students in the GMO debate?

– for whom and why?

Will the students be able to use some of the knowledge they obtained about GMO purity in laboratory work in this debate? (Is deep-learning stimulated?)

What impact will this lecture type have on the Egyptian students vs. the mixed student groups?

– will there be a difference?

Theoretical part: The interactive lecture vs. the traditional lecture as teaching form

Traditional lecture

My definition of a traditional lecture is a lecture where the teacher presents scientific facts (usually) to a larger group of students. This teaching format has for several centuries been the dominant teaching form at universities around the world. The traditional lecture is a monologue and the teacher might succeed in getting the students to learn concepts and to identify a procedure. However, it can often be very difficult for the student to get a qualitative level of understanding solely from lectures. On the other hand, traditional lectures are very time and cost efficient as a large amount of students (several hundreds) can be taught at the same time by one teacher. This fact is an important aspect when planning the teaching of a course. However, the last decades have shown that other formats of lectures might improve the students' deep learning (see below).

Interactive lecture

Before planning the interactive lecture format, I browsed the literature based on what I had learned through the KNUD course part, and the chosen theoretical aspects are discussed in the following paragraphs. Based on observations made by Eric Mazur, a teacher at Harvard University, an interactive teaching format was developed in the late 1990s (Crouch & Mazur; 2001; Mazur; 1996). One of the starting points was that Mazur tested his students and found that they relied on memory rather than understanding. Mazur then applied multiple-choice questions, the students' answers were recorded electronically by "clicking" the answers, and the total outcome of the results was shown on a screen. Afterwards, the students discussed their answers with neighbouring students that answered differently and they elaborated their answers together. Mazur aimed for a high level of understanding and stimulated the students by using student activities like discussing novel problems and application of knowledge gained from reading. Collectively, these activities should improve the students' deep learning (higher student retention rates) as shown in the lower sections of the Learning Pyramid (Fig. 7.1).

Similarly, other teachers like David Yamane were also annoyed by the inefficiencies of lecturing, as the students did not read when they were told to. Hence, he posted course preparation assignments on the course web page before the lectures (Yamane; 2006). Mazur and Yamane both experienced that the interactive lecture format stimulated the students' learning as they became motivated and enjoyed it. However, Mazur and Yamane were also aware of the potential class size limitation for using this lecture format and mentioned the limits to be in the range of 30-80 students. Another important aspect in promoting deep learning for the students is to change the teaching activities often. Bligh (1972) found that student concentration flags after approximately fifteen minutes, particularly if the teaching ac-

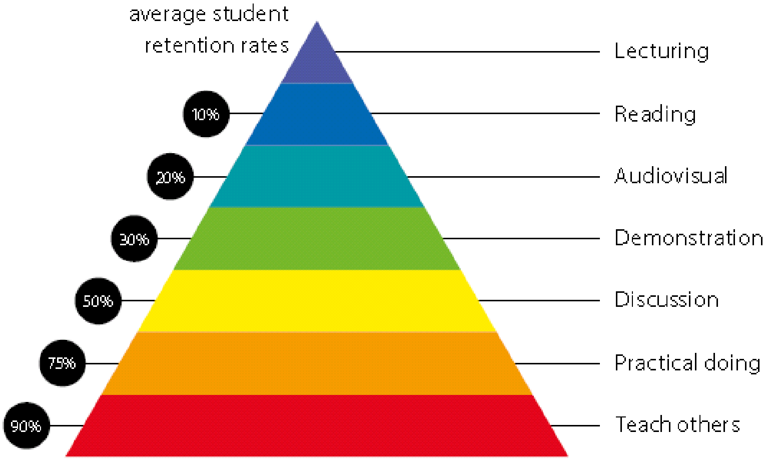


Fig. 7.1. Learning Pyramid. National Training Laboratories, Maine, USA.

tivity is listening (Fig. 7.2). The teaching activities can be changed by, for example asking the students questions, providing them a case study to work on, and letting them reflect on what they have learned, which will increase the students' focus (Fig. 7.2).

In the following scheme (Fig. 7.3), I have compared and reflected on some positive (+) and negative (-) basic aspects of the traditional and interactive lecture that I found important when I planned my lectures.

Lecture planning

Based on my abovementioned observations on how the students perceived the traditional lectures that I gave at the seed science course when I taught it in previous years and the potential theoretical benefits, I planned an interactive lecture.

My teaching part in the seed science and technology course is divided roughly equally between lectures and exercises. In order to vary the teaching type and output to keep the attention of the students, first of all, I decided to divide the exercise part into segments and separate them out on

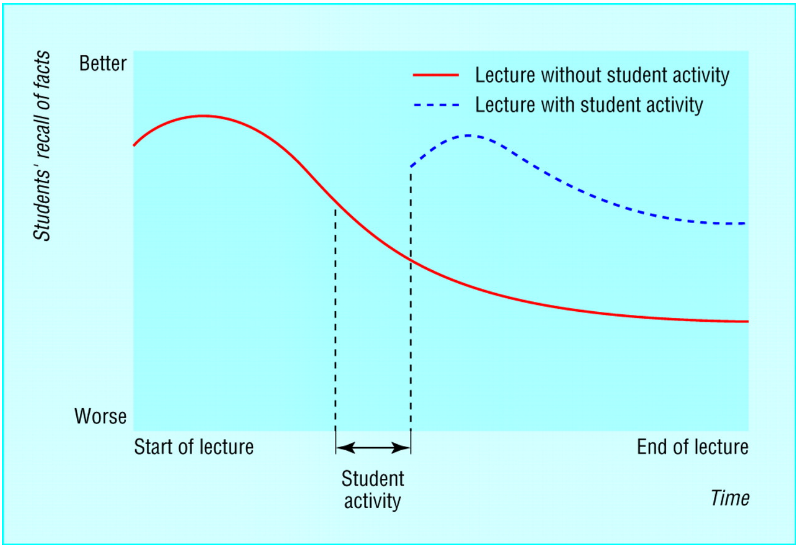


Fig. 7.2. Student learning over time and how to improve it. Modified from Bligh (1972).

Traditional lecture		**Interactive lecture**	
+	-	+	-
Time & cost efficient Many students can be taught at the same time			Longer preparation time for the teacher. Smaller classes
Delivery of facts and scientific concepts	No application of facts and scientific concepts	Application of facts and scientific concepts	
	Passive teaching / monologue	Active teaching / dialogue	
		Deep learning	

Fig. 7.3. Basic aspects of the traditional and the interactive lecture.

the three course days (see course part plan for the regular course in Appendix A). Next, I applied a concept gradient of my ownership of the teaching, gradually going from “hands on” to “hands off” during the time span of the lecture parts. This meant that the introduction lecture was a traditional lecture that was monologue-based. The second lecture was interactive, whereas the last “lecture” was solely based on input and presentations from the students. The planning and reflections of the three lectures will be discussed more thoroughly below.

Planning the introduction and traditional lecture

As this lecture was an introduction, it was controlled with “hands on” from my side. I felt that this would be the most efficient method to introduce the course plan and the topic itself to the students and to deliver some scientific facts and basic concepts. However, time was set aside to answer questions and the students were allowed to interrupt if they had questions popping up. Approximately one week prior to my part of the regular course, I uploaded the programme as a bulletin on the course web-page at Absalon, stating that the students should read and bring the plan for this part. Moreover, non-compulsory background literature was uploaded as well.

Planning the interactive lecture

This lecture started with an “exercise sum-up”, where specific questions were given to the students in respect of what they did in the lab on the first day. After that, I presented a case study covering some of my own research on how compact potted plants can be produced by using three different GMO methods as an environmentally friendly alternative to chemical growth retardants. For each of the methods, some specific features were presented (Appendix B) and the students were asked to give an opinion regarding whether they were for or against the specific feature. To do so, the students were given green and red sheets, to hold in the air to indicate their opinion, “for” or “against”, respectively. This feature was chosen as a representative for the “clickers” Mazur used, mentioned above. Moreover, the students were given time to elaborate on their answers. The case study ended with a question asking the students to prioritize the three methods which led up to a discussion if or where general ethical lines can be set (Appendix C). After the interactive lecture, a student assignment was given on EU GMO regulation (Appendix D) forming the basis for the student presentation lecture (see below).

Planning the student presentation lecture

Again, the lecture started with an "exercise sum-up", where specific questions were given to the students in respect to what they did in the lab the last time. A student assignment was given on EU GMO regulation (Appendix D) forming the basis for the student presentation lecture, where the students were divided into teams. My idea behind the student presentation lecture was to give the students the opportunity to introduce themselves to the three phases in EU GMO application by giving them an internet link and providing them with possibilities to find answers to the questions mentioned in Appendix D. Furthermore, due to peer supervision feedback, I included a case study on "transgenic cotton" (Appendix D). In the case study, the teams were asked to provide opinions from the respective viewpoints of a biotech company, the EU and the public. The overall purpose was to see how at the end of the course the students would be able to apply their knowledge to discuss relevant aspects regarding the scientific subject with only minimal interference from me.

Results

When I started to give the introduction lecture in the regular version of the course, I experienced that it was difficult to catch the attention of all the students as some kept on talking. Hence, I deviated a bit from my plan by asking questions of the students, this caught their attention and I kept on asking short questions with an interval of some minutes. In contrast, on the Egyptian version of the course, all the students listened carefully from the beginning. The majority of the course participants at the regular version of the course had actually read the programme in advance – in contrast to other years, where I did not specifically ask them to do so – which helped their understanding of the course part. (As the Egyptian students are not enrolled at the University of Copenhagen, the programme was handed out on the first day).

In the interactive lecture, I found that the experimental sum-up was a very good idea to start with, as I quickly discovered which aspects I needed to address more thoroughly to improve the students' understanding. During the case study part, where the students were asked to provide their opinions on specific features, I experienced that several of the students on the Egyptian version of the course were looking around sort of trying to figure out what the “right opinion” would be to that specific feature. In contrast, at the regular course the students actively elaborated on their opinions and discussions were initiated.

For the student presentation lecture, my overall feeling was that it was a bit difficult for some of the students attending the Egyptian version of the course to be able to present the essential features specific to the three GMO approval phases in EU. When the students were preparing themselves, I experienced that it sometimes was difficult for them to navigate around the various links at the homepage. However, the Egyptian students were highly motivated in presenting the cotton case study. On the regular version of the course, I found that the students were very active in both the legislation part and the case study. Several had prepared PowerPoint presentations, even though it was not mandatory.

Evaluation and conclusion

To obtain information on how the students perceived my teaching, I constructed the evaluation scheme shown in Appendix E. The answers of the Egyptian students and the regular students are highlighted in blue and pink, respectively.

As the Egyptians in their home country are only used to traditional one-way directed lectures, I felt it was very important to ask them how they perceived the interactive lecture format. Rather contrary to my initial expectations, 87% of the Egyptian students preferred the interactive lectures. However, when I discussed the interactive lecture format with the Egyptian students they elaborated and said that at first they found the format a bit annoying, but gradually they felt they gained more knowledge that way. At the regular version, most students also favoured the interactive lecture, but some also mentioned that there should be a mix between interactive and traditional lectures.

The majority of the students on both versions of the course mentioned that they had learned both the basic molecular and legislation concepts for GMO and plants. The majority stated that they liked the laboratory part best, but whereas all the Egyptians found that the lab work was most important, a large part of the students at the regular course found that the discussions were important as well.

In respect to what should be improved, their answers were more varied, but a few mentioned lectures, so I will develop these further next year.

In conclusion, the majority of the students on both versions of the course favoured interactive lecturing over traditional lectures, and it stimulated their activities and they were able to participate more actively in the discussions than what I experienced when I taught at the course previously.

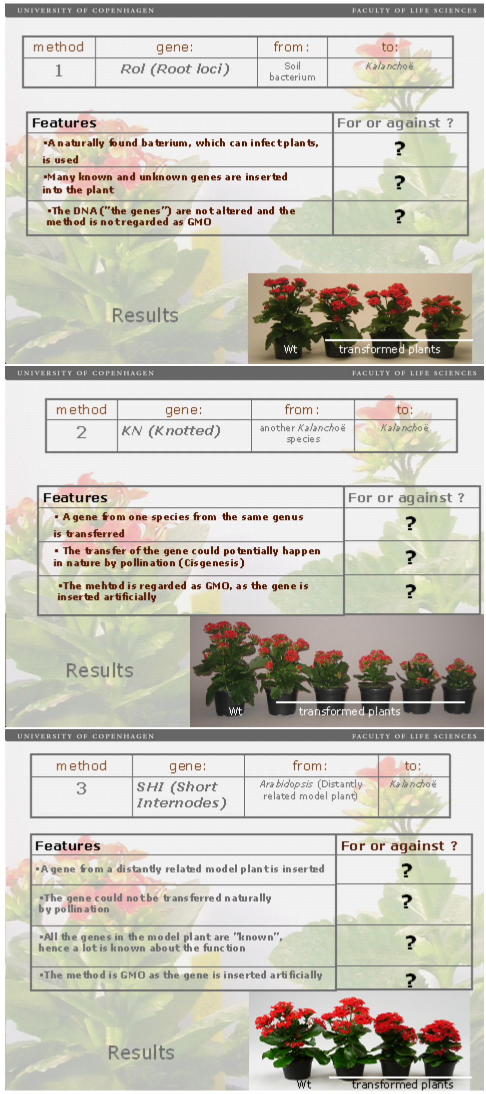
Perspectives

The students at the Seed Science and Technology course are usually an equal mix of Danish and foreign students, as mentioned above. This feature often provides a good forum for interactive lectures as debates and discussions due to different backgrounds and opinions from the students are easy to initiate. Hence, it was pleasing to experience that a homogeneous group of students from Egypt also favoured this lecture format, even though they have only experienced traditional lectures. However, when comparing the Egyptian version of the course with the other times I taught at the course with a mixed group of students, I feel that certain precautions are necessary. For instance, I think that on all the courses I teach in the future I will use slightly different versions of lectures depending on the composition of the participating students, as I believe that small adjustments can improve the learning outcome without too much effort by the teacher. In the problem definition, I stated that I would let the students work in pairs rather than groups. However, the groups already formed in the course consisted of two or three persons, so I decided to keep this structure, and I experienced that the students collaborated very well within these groups.

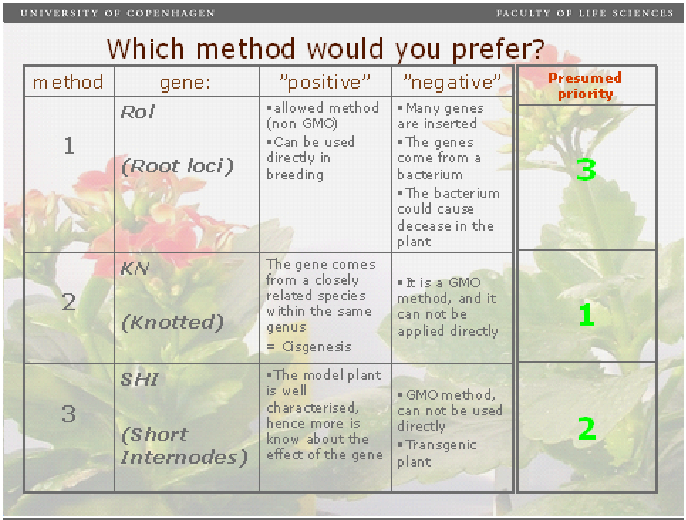
A Course part plan

Tuesday 12/10	*Programme*	*Location*
8.45-9.45	**Introduction to the exercise:** **Extraction of seed DNA** **The principle behind polymerase chain reaction (PCR)**	**P11**
9.45-10	**Small break**	
10-12	***Exercise:*** **Purify DNA from seeds using 2 extraction methods**	**Laboratory #15**
Friday 15/10	*Programme*	*Location*
8.45-9.45	***Exercise:*** **Set up PCR**	**Laboratory #15**
9.45-10	**Small break**	
10-11	**Interactive lecture:** ***Molecular breeding in ornamentals as an alternative to chemical growth retardants*** ***Which method do you prefer and why?***	**18.01**
11-12	**Student assignment will be given:** **EU GMO regulation at:** **http://www.gmo-compass.org/eng/regulation/regulatory_process/**	**18.01**
Monday 18/10	*Programme*	*Location*
8.45-9.45	***Exercise:*** **Making gels, running gels**	**Laboratory #15**
9.45-10	**Small break**	
10-11	**Student presentation of the EU assignment** **GMO discussion**	**18.01**
11-12	***Exercise:*** **Evaluate experiment**	**Laboratory #15**

B

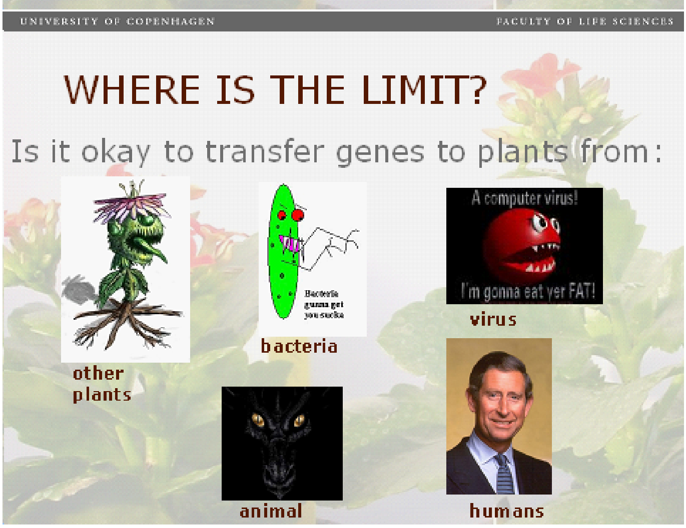

UNIVERSITY OF COPENHAGEN
FACULTY OF LIFE SCIENCES
method
gene:
from:
to:
1
Rol (Root loci)
Soil bacterium
Kalanchoë
Features
For or against ?
•A naturally found baterium, which can infect plants, is used
?
•Many known and unknown genes are inserted into the plant
?
•The DNA ("the genes") are not altered and the method is not regarded as GMO
?
Results
Wt
transformed plants
UNIVERSITY OF COPENHAGEN
FACULTY OF LIFE SCIENCES
method
gene:
from:
to:
2
KN (Knotted)
another Kalanchoë species
Kalanchoë
Features
For or against ?
• A gene from one species from the same genus is transferred
?
• The transfer of the gene could potentially happen in nature by pollination (Cisgenesis)
?
•The mehtod is regarded as GMO, as the gene is inserted artificially
?
Results
Wt
transformed plants
UNIVERSITY OF COPENHAGEN
FACULTY OF LIFE SCIENCES
method
gene:
from:
to:
3
SHI (Short Internodes)
Arabidopsis (Distantly related model plant)
Kalanchoë
Features
For or against ?
•A gene from a distantly related model plant is inserted
?
•The gene could not be transferred naturally by pollination
?
•All the genes in the model plant are "known", hence a lot is known about the function
?
•The method is GMO as the gene is inserted artificially
?
Results
Wt
transformed plants

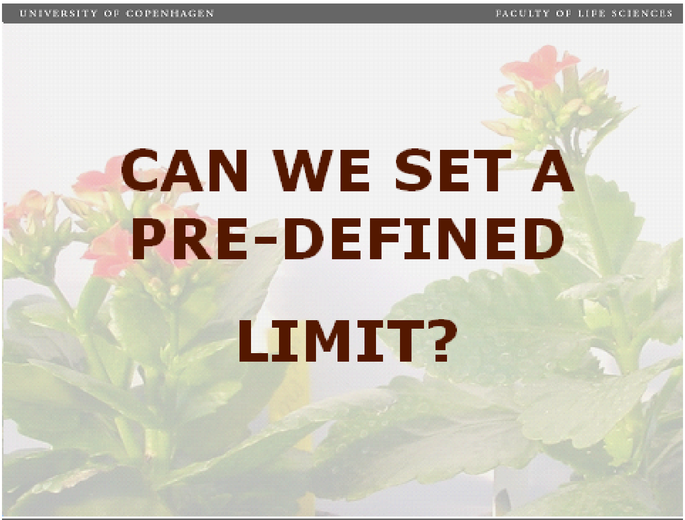
C

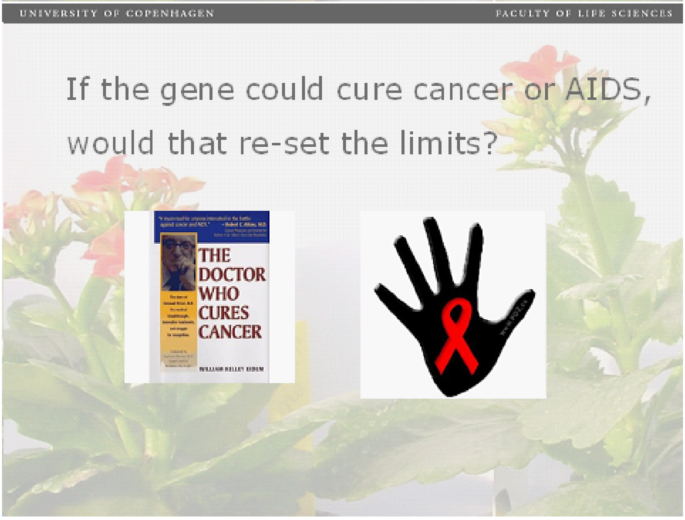

UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

Which method would you prefer?

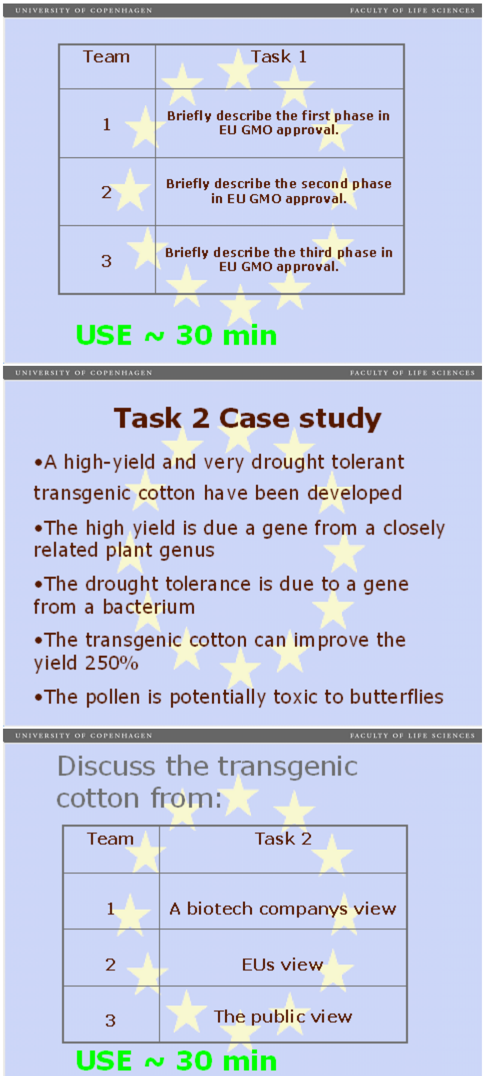
method	gene:	"positive"	"negative"	Presumed priority
1	*Rol* (*Root loci*)	▪allowed method (non GMO) ▪Can be used directly in breeding	▪Many genes are inserted ▪The genes come from a bacterium ▪The bacterium could cause decease in the plant	3
2	*KN* (*Knotted*)	The gene comes from a closely related species within the same genus = Cisgenesis	▪It is a GMO method, and it can not be applied directly	1
3	*SHI* (*Short Internodes*)	▪The model plant is well characterised, hence more is know about the effect of the gene	▪GMO method, can not be used directly ▪Transgenic plant	2




UNIVERSITY OF COPENHAGEN
FACULTY OF LIFE SCIENCES
CAN WE SET A PRE-DEFINED
LIMIT?


UNIVERSITY OF COPENHAGEN
FACULTY OF LIFE SCIENCES
If the gene could cure cancer or AIDS, would that re-set the limits?
THE DOCTOR WHO CURES CANCER

D


UNIVERSITY OF COPENHAGEN
FACULTY OF LIFE SCIENCES
Team
Task 1
1
Briefly describe the first phase in EU GMO approval.
2
Briefly describe the second phase in EU GMO approval.
3
Briefly describe the third phase in EU GMO approval.
USE ~ 30 min
UNIVERSITY OF COPENHAGEN
FACULTY OF LIFE SCIENCES
Task 2 Case study
•A high-yield and very drought tolerant transgenic cotton have been developed
•The high yield is due a gene from a closely related plant genus
•The drought tolerance is due to a gene from a bacterium
•The transgenic cotton can improve the yield 250%
•The pollen is potentially toxic to butterflies
UNIVERSITY OF COPENHAGEN
FACULTY OF LIFE SCIENCES
Discuss the transgenic cotton from:
Team
Task 2
1
A biotech companys view
2
EUs view
3
The public view
USE ~ 30 min

E Evaluation of the GMO course part

Did you learn the basic molecular concepts for GMO and plants?
Egyptian: yes: 6/6=100%.
Regular: yes: 10/14=71.4%, no: 2/14=14.3%, did not participate all days: 2/14=14.3%

Did you learn the basic legislation concepts for GMO and plants?
Egyptian: yes: 5.5/6= 92%, no: 0.5/6=8%
Regular: yes: 12/14=85.7%, not answered: 2/14=14.3%

What did you like in particular?
Egyptian: lab work 5/6=83%, GMO legislation: 1/6 = 17%
Regular: lab wok: 10/14=71.4%, GMO legislation: 3/14=21.4%, student presentation: 1/14=7.1%

Which aspect did you find most important?
Egyptian: lab work 6/6=100%
Regular: lab work: 7/14=50%, discussions: 6/14=42.9%, not answered: 1/14=7.1%

What do you think should be improved?
Egyptian: lectures: 2/6 = 33.3%, more material: 1/6=16.6%, nothing: 1/6=16.6%, PCR protocol: 1/6=16.6%, homework and more material: 1/6=16.6%
Regular: nothing: 9/14=64.3%, nothing/really good: 1/14=7.1%, more time: 3/14=21.4%, lectures (GMO legislation), 1/14=7.1%

Did you like the interactive lecture format or would you prefer traditional lectures?
Egyptian: interactive: 5/6= 83%, traditional lecture=17%
Regular: interactive: 11/14=78.6%, a mix of both: 2/14=14.3%, only used to traditional lectures in home country, but found the interactive lecture interesting: 1/14=7.1%.

Rate the course part:

Bad	Room for improvement	Okay	Fine	Excellent
		Regular: 1/14=7.1%	Egyptians: 2/6= 33.3% Regular: 10/14=71.4%	Egyptians: 4/6= 66.7% Regular: 3/14=21.4%

Other comments:

Egyptian: none: 66.6%, more time for understanding: 16.6%, more handouts: 16.6%,

Regular: none: 11/14=78.6%, more PCR theory: 1/14=7.1%, less PCR theory: 1/14=7.1%, address organic seeds: 1/14=7.1%.

8

Assessing reflective thinking and analytical skills in final exams

Pernille Kæstel

Department of Human Nutrition, LIFE, University of Copenhagen

Introduction

Since I worked with the pre-project for a higher education teaching course, I have changed my attitude towards exams. Previously, I did not acknowledge exams and marks as a driving force for students' motivation and learning process. However, during my pre-project work, I realized that exams and marks are important for students. Many students need exams as immediate goals, although they also know that learning is not for the exam, but for life. Therefore, we should use the exams wisely and make sure we test what we expect the students to learn and not something else. If we are successful in doing so, exams can facilitate students' learning processes. But we should be careful not to teach the students one thing, test them in another thing, and actually want them to learn something different.

It is my impression that even in postgraduate courses, far too often exams are testing the ability to copy and repeat exact knowledge (surface learning) rather than scientific abilities in more advanced levels of the learning hierarchy. And students tend to learn what the tests reflect (Biggs & Tang; 2007). Unfortunately, students often tend to believe that they have to learn facts and theories by heart and be able to remember and copy what the lecturers tell them, in order to obtain good marks in exams (Andersen; 2005). If this is what is practised in exams, then they are useless and may even be harmful. In order to give direction for the students and to assist in the learning process, the teaching activities and assessment should be coherent with the intended learning outcome. The course should be constructively aligned.

In the following, I will focus on the exam, and how we can address reflection and critical thinking in the exam, and how to evaluate the quality of the student performances.

The context: The course and its environment

The model course chosen for this project is "International nutrition and health, course no. 270083", a non-compulsory 7.5 ECTS postgraduate course offered at LIFE. The students are typically from the MSc programmes in Human Nutrition or Agricultural Development, a number of foreign exchange students typically with food science or agricultural science background, and a few public health students. The number of students is normally between 25 and 35.

The learning objectives for the course are presented as knowledge, skills and competences, but still somehow reflect the course content rather than the learning objectives. Some of the learning objectives for the course are evaluated during continuous assessment by smaller group-based reports which should be submitted and passed in order to register for exam. The learning objectives, in their current form, are a bit difficult to use as a basis for the exam, as many are topic specific, and therefore difficult to apply in an exam unless each topic is covered in the exam. If the general learning objectives are reflective thinking, analytical skills, overview and understanding within the context of the course topics, then these abilities do not need to be demonstrated for each topic in the exam.

In addition, in my opinion, there are some more general academic tools which must be assessed in postgraduate exams. Maybe it would be an idea to include some of these as explicit learning objectives for the course as well. Relevant examples of these are: analytical skills, ability to identify, digest and analyse relevant information, clarity and conciseness in writing, etc.

Course history, past experiences and reflections

Previously, the final assessment of this course was pass/fail of a written group report based on a student-chosen subject. Since the group evaluation as an assessment form was abandoned a few years ago and we did not want to stimulate the students to combine individual work and call it group work, we decided to change the assessment form and introduced an individual 48-hour take-home exam as the final assessment. In 2009 it was conducted as a pass/fail exam. However, for two reasons, in 2010 we decided to give marks for the final exam. First of all, exchange students need marks in order to get credits for their course work at their home university. Secondly, the course is competing for student engagement and motivation with other courses taken simultaneously, and we had a few bad experiences with some students who took the course to collect some easy ECTS which negatively affected the whole learning environment. In conclusion, we decided to assess this course from 2010 with a 48-hour take-home exam with marks.

To avoid student confusion and frustration about the exam, and to develop the format, we introduced an individual assignment halfway through the course which was modelled on the final exam. It gave the students an idea of the form and the expectations, and in addition, it gave us some material for developing types of questions. We are definitely going to repeat this session in the coming years as it was well received by the students and in addition provides an opportunity for formative assessment and timely feedback which the students can use in their learning process.

Using this individual assignment before the final exam also improves the transparency of the assessment criteria and explicitly shows the students what we expect from them. If the assignment is properly designed and reflects what we want the students to learn, the students' learning may become more focused. By introducing rehearsal, the students will feel more prepared for the final exam and the assessment criteria become more transparent, which may also improve student performance (Johnsson; 2010).

The individual take-home assignment as a learning tool and as a final exam

The way we approach this 48-hour exam is by selecting one or two scientific papers which address one or two main course topics, but have not previously been used in the course. It is not an essay, but rather it consists of a number of focused questions which relate directly or indirectly to the papers. First, the students are expected to read and understand the texts and then use the texts directly as a basis for their answers. The specific tasks may be to extract the most important messages from the papers, to explain some figures, to discuss specific findings, to relate the findings to other content covered in the course etc. It may also be to identify knowledge gaps in the actual papers and search for further information via the internet.

The extended time removes the focus from time pressure and introduces time for reflection and discussion. In many ways, it reflects a real life situation where academics can search for information, discuss, and digest knowledge before they provide answers to a given problem. Students are allowed to discuss the assignment with colleagues, friends and family, and to search for information, and they have time to read and investigate, to think and reflect. Finally, they have to wind it all up in their own individual written answer. The exam does not leave much room for plagiarism as the students are unlikely to be able to find and copy answers to the specific questions.

It enables the students to demonstrate a variety of skills and competences. It is not merely assessing declarative knowledge, which unfortunately many other exam forms do. I think it is a potentially very useful exam with many advantages and few disadvantages (time consuming to evaluate) and if well planned it can work perfectly as part of a postgraduate course aiming at student ability to crystallize information from scientific papers and reports and discuss it in the course-specific context.

Design of questions and development of a generic grading rubric

Different competences need to be assessed using different types of questions or tasks (Biggs & Tang; 2007). Hence, the final exam should use a variety of assessment tasks to assess a variety of competences rather than merely declarative knowledge (Biggs & Tang; 2007).

Together with my colleague, associate professor Nanna Roos, we developed and selected five types of questions because they address different competences which we want the students to obtain (Fig. 8.1). I have then seen these questions as representatives for some more general types of questions and elaborated on which competences they assess.

Most of the questions address learning at a high level of understanding and in addition, they reflect different aspects of the desired competences. This is a major advantage, as the assessors may focus on specific competences during assessment of the different tasks.

So far so good – a thoughtfully designed assignment is the first step towards a successful exam. However, the student contributions have to be

Type of question/task	Competences addressed
Introductory questions *Basic understanding of text and topic*	Address *basic understanding* of the text: Mainly included in the assignment to get the students into the game, to make sure that everyone feels they can get started and get going. These questions will not count much in the overall grade as they only address very basic skills.
Discussion questions *Discuss main findings, contradictory results or surprising findings*	Address *depth of knowledge and scientific overview* and ability to transform critical thinking into a well structured and balanced discussion.
Illustrate *Illustrate numbers from the text in alternative ways and comment on the figure*	The students are asked to extract figures or numbers from the text, illustrate them in an alternative way (as a diagram, a figure, a plot) and comment on their figure. This addresses wider understanding and *ability to use the available information in another way and present it in an appropriate way*. Assesses the ability to take the information a step further, out of its immediate context and present and interpret meaningfully.
Prioritize information *Suggest and prioritize actions to take based on the findings in the text*	For example suggest and *prioritize* at least three solutions to a given problem. Answers should always be justified and based on context relevant arguments. This task assesses familiarity with and overview of relevant knowledge within the scientific area, *ability to reflect* and *professional confidence* to prioritise the suggested actions according to importance.
Identify new information *Identify databases, literature or reports of relevance for the specific question.* *Evaluate and present the information*	Address the ability to *search for, identify and select appropriate information* needed to fill a predefined knowledge gap. This type of question may also entail an evaluation of the strengths and weaknesses of the identified information, and *identification of knowledge gaps*, or to suggest new approaches.

Fig. 8.1. Types of assessment tasks and the competences they address.

assessed and marked as well. As such, there is rarely one right answer in this type of assignments, but the quality of the performance is rather determined by the strength of arguments, the demonstration of overview and deep understanding, the structure and the organization of the answer.

Criterion-based assessment will be applied to the exam assignments (Biggs & Tang; 2007). With this approach, students are not ranked, the marks are not supposed to follow any normal bell-shaped curve, but the performances are independently assessed according to some pre-specified criteria. In order to increase the transparency and fairness and to smooth the progress of the assessment, it may be useful to design a rubric which clearly defines the assessment criteria for each element in the final exam (Mertler; 2001). Figure 8.2 presents a rubric developed to assess the different types of questions suggested for the 48-hour exam with an overall focus on critical thinking (Peirce; 2010).

Question type	Suggested assessment criteria according to the 7 point scale						
	Excellent		Good	Fair		Insufficient	
	12	10	7	4	02	00	- 03
Introductory questions ***Basic understanding of text and topic***	Accurately describes the main message, demonstrating full understanding of the text	Accurately describes the main message, demonstrates good understanding of the text	Adequately describes the main message, demonstrating good understanding of the text	Adequately describes the main message, demonstrating good understanding of the text	Evidence of some misunderstandings or misinterpretations of main results from the text	The most basic messages are misunderstood and misinterpreted	
Discuss main findings, contradictory results or surprising findings	Identifies relevant arguments and limitations Convincingly analyses and evaluates major points of surprise Draws sound, balanced and precise conclusions Clearly distinguishes between evidence and opinion	Identifies relevant arguments and limitations Adequately analyses and evaluates major points of surprise Draws sound, balanced conclusions	Identifies relevant arguments Adequately analyses and evaluates major points of surprise Draws right but slightly unfocused and vague conclusions	Identifies some relevant arguments Analytical level is superficial and unfocused Draws unfocused and vague, maybe wrong conclusions	Identifies few and poor arguments Analytical level is superficial and unfocused Draws vague and maybe wrong conclusions	Lists some arguments but they are poorly used to discuss the findings Vague or wrong conclusions Analytical level superficial Lists own ideas, unsupported by the course content	
Illustrate numbers from the text in alternative ways and comment on the figure	Identifies the relevant numbers and convert them wisely and creatively into alternative presentation form. Demonstrates complete understanding and ability to use appropriate terms in presenting the figure	Identifies the relevant numbers and convert them wisely and creatively into alternative presentation form. Demonstrates ability to use appropriate terms in presenting the figure	Identifies relevant numbers but presents them in a less obvious way Presentation and description of the figure may be a bit unclear or insufficient	Misunderstands the assignment and creates a framework/figure which does not relate to the actual numbers Presentation and description of the figure may be a bit unclear or insufficient	Misunderstands the assignment and creates a nonsense framework/figure which does not relate to the actual numbers Presentation and description of the figure unclear and insufficient	Misunderstands the assignment and creates a nonsense framework/figure which is not appropriately presented	
Suggest and prioritize actions to take based on the findings in the text	Demonstrates scientific confidence to select and prioritize actions in a given context The prioritized order is logical and based on valid arguments Strong evidence of familiarity with relevant literature	Demonstrates scientific confidence to select and prioritize actions in a given context The prioritized order is logical and based on valid arguments Shows familiarity with relevant literature	Suggests context appropriate actions Prioritization maybe unclear or absent Shows familiarity with relevant literature	Suggests context appropriate actions, but fails to prioritize Answer lacks focus and does not refer to relevant literature May be an unjustified list of ideas	Presents an unjustified list of ideas in random order Does not take context into consideration Limited evidence of understanding of the course content	Presents an unjustified list of ideas in random order Suggestions are irrelevant or at least inappropriate	

Continues on next page…

...continued from previous page

Question type	Suggested assessment criteria according to the 7 point scale						
	Excellent		Good	Fair		Insufficient	
	12	10	7	4	02	00	- 03
Identify further data/information ***Browse the internet and identify databases, literature or reports of relevance for the specific question.*** ***Evaluate and present the information***	Appropriate information was identified and critically evaluated according to quality, source and relevance Information is convincingly presented, its strengths and limitations mentioned and the conclusions fully reflects the identified strengths and weaknesses	Appropriate information was identified and critically evaluated according to relevance Information is convincingly presented, its strengths and limitations mentioned and the conclusions are balanced	Appropriate information was identified Information is adequately presented, and the conclusions are balanced The data quality is evaluated based on its origin (organisation) rather than by its quality *per se*	Some information was identified and adequately presented but the conclusions may be wrong or exaggerated The evaluation of the data quality is either absent or based on its origin (organisation) rather than by its quality *per se*	Some information was identified and shown but the conclusions may be wrong or exaggerated The evaluation of the data quality is absent	irrelevant information was identified and shown and the conclusions may be wrong or exaggerated The evaluation of the data quality is absent	
Overall impression of the assignment. ***Organisation and structure.*** ***Capacity to use relevant arguments.*** ***Clear and concise text***	Language is clear and concise Conclusions are balanced but as strong as possible Evidence of extensive understanding of the course content Structure, organisation and presentation is convincing and well-developed	Language is clear and concise Conclusions are balanced but as strong as possible Evidence of good understanding of the course content Text is well structured, organised and presented	Language is generally clear with some imprecision Conclusions are balanced but maybe a bit vague Evidence of good understanding of the course content Text may lack a bit of focus and accuracy	Language is generally unclear and messy Conclusions are vague or wrong Only demonstrates limited understanding of the course content Answers are not well structured but may merely consist of lists of arguments	Language is generally unclear and messy Conclusions are vague or wrong Demonstrated lack of understanding of the course content Answers are poorly structured and may merely consist of lists of arguments	Language is widely unclear and shows major lack of academic writing skills Conclusions are vague or wrong Demonstrated lack of understanding of the course content	
Final mark							

Fig. 8.2. A generic grading rubric. Criteria are not included for -03 as it was difficult for me to imagine a situation where a contribution is worse than 00.

The rubric was designed from the left side, at which end the highest performances are placed. In other words, the first column resembles the perfect answers. Moving to the right, there is room for some mistakes or limitations. Finally, the last column represents answers which will fail. I only added one "fail" category, as my imagination has difficulties in seeing the performance which is worse than none (-03). The students' answers may be very different, but different answers may very well be of the same academic quality, and a rubric like this may assist in the grading process to fairly reward the good performances. It has to be finally decided how much weight the different questions are given. The basic understanding and knowledge may be given lower weight than the more advanced higher level thinking.

Unfortunately, we did not manage to have this tool in place before the exam this year, but it was prepared based on the experiences with assessing the assignments and we will apply it next year. I am convinced that this tool will make the assessment process smoother and fairer in the future.

Conclusion

The development of the exam and the assessment tool is going to be a continuous process. It may involve a revision of the course ILOs, as well as to make sure they are coherent with the teaching activities and the final assessment. What we want the students to learn should be the heart of the course, supported by the teaching activities and properly assessed by the exam. The course ILOs should preferably be on a higher more general course level, supported by the specific content-oriented ILOs for each teaching activity. The course ILOs can then be addressed in the final exam regardless of the topic.

There is still a lot to learn, and definitely still room for improvement. The first step is, indeed, that we as teachers become clearer about what we expect the students to learn and are explicit about how we will assess it. This process has now started and a little extra investment of thought will definitely improve the course, the exam, the fairness and the transparency of the evaluation process for the students.

Tests should not be overemphasized, but should not be neglected either as they play a central role in student motivation and thereby potentially in the learning process. If properly designed and reflecting the teaching, the exams may enhance the learning process, while if poorly aligned with the teaching exams may negatively affect the learning. As long as we can use the exams to enhance the students' learning process, they are useful and most welcome in my future courses.

Part II

Lab work, exercises and group work

9

Active students in problem-solving classes

Anders Ø. Madsen

Department of Chemistry, SCIENCE, University of Copenhagen

Introduction

MatIntro is an introductory course in calculus at the University of Copenhagen. It is a mandatory course for a range of studies, including mathematics, physics, chemistry and biochemistry. The course has been running for about seven years in its present form. Compared with previous introductory courses in mathematics for biochemistry students, the course has been successful in obtaining a much higher pass rate. However, there is still a large gap between the exam results and the pass rates of the biochemistry students and the chemistry, mathematics and physics students.

I have previously analyzed the structural alignment of the course as well as the overall alignment of the biochemistry study plan (KNUD written assignment on structural alignment). The analysis showed that parts of the internal alignment were good – i.e., the intended learning outcomes (ILO), the teaching-learning activities (TLA) and the assessment of MatIntro was well aligned. However, it also showed that some aspects of MatIntro lead to *passive students* and a *surface approach to learning*. These aspects include the assessment, which is partly based on a multiple-choice exam, the workload – including weekly hand-ins and a very tight schedule in order to cover a large curriculum, as well as a lack of peer-to-peer learning activities. Group work used to be an important aspect of the course, but Danish legislation now prohibits group exams, and this has changed the student motivation for group work quite significantly.

The analysis also demonstrated that mathematics does not play an important role in the biochemistry Bachelor programme study plan, and that there is a misalignment between the overall study plan ILO and the way mathematics is presented to the students in MatIntro.

The present project

During September and October 2010 (block 1 at the University of Copenhagen) I was the class teacher for thirty-two biochemistry students on the MatIntro course, and I used this teaching as an opportunity to test out some ideas to *improve student activity* and *active learning* for this very common type of "problem-solving" mathematics classes. The setup is classical – a number of exercises are handed to the students some days before class. During the class hours, the students and teacher will discuss or calculate the exercises. Depending on the ability and motivation of the students, the students have prepared in some way for the class. Typically, five to ten students arrive having prepared quite well, while other students have not prepared at all.

Focus, delineation

As a teacher for a problem-solving class, I am, of course, not in a position where I can change either the intended learning outcomes or the assessment of the course. And since these aspects have already been analyzed in my previous assignment, it makes sense to focus on the teaching-learning activities in the problem-solving classroom. Of course, these activities have to be aligned with the ILOs and assessment. In order to discuss the alignment of new TLAs to the ILO and assessment, I repeat parts of the discussion about alignment and have reproduced the course ILO in figure 9.1.

Alignment of ILO and assessment

These ILOs fulfil some of the criteria of the intended learning outcomes that are recommended in outcomes-based teaching (Biggs & Tang; 2007). The sentences used to describe the different outcomes state very clearly what the students should practice doing during the course.

The final summative assessment, which consists of two multiple-choice tests, is well-aligned with the ILOs: The multiple-choice tests are in my

Present ILOs for the MatIntro course:

Aim:
At the ends of the course the students should be capable of:
1. Following proofs
2. Solving problems with or without the computer algebra system Maple.
3. Mastering the subject matter content described below.

Course description:
Use of Maple
1) Complex numbers.
2) Number sequences.
3) Continuous functions in 1 variable.
4) Differentiability and integration of functions in 1 variable.
5) Continuity of functions of several variables, topology of R^n.
6) Differentiability of real functions of several variables.
7) Extrema for real functions of several variables, Lagrange's method.
8) Taylor's formula.
9) Surface and volume integrals.
10) Solution of simple differential equations, numerical integration.

Expected competencies:
By the end of the course the student must be capable in general to follow mathematical language and reasoning within the subject of the course, and specifically be able to
- o perform arithmetic with complex numbers,
- o decide convergence and determine limits of real sequences,
- o determine limit values of functions,
- o perform computations involving continuity considerations,
- o perform differentiation and integration of functions of 1 variable,
- o solve basic differential equations of order 1 and 2,
- o determine Taylor polynomials and estimate remainders for functions of 1 variable,
- o decide simple topological properties of planar sets,
- o perform differentiation and apply the chain rule to functions of several variables,
- o describe a function geometrically by means of graphs and level curves,
- o determine the tangent/tangent plane of a graph or level set in plane or space,
- o examine extrema of functions, with or withour constraints,
- o pose and compute double and triple integrals,
- o give correct arguments in applications of theory and methods,

and in addition use Maple, when relevant in association to the above.

Fig. 9.1. ILOs for the MatIntro course.

opinion sufficiently effective in assessing whether the students are able to perform the ILOs given above.

In the SOLO taxonomy (Biggs & Tang; 2007, p. 76ff), these highly quantitative ILOs encourages uni-structural and multi-structural knowledge. It could be argued that this level of operational knowledge is sufficient on a first-year introductory "toolbox" course.

Motivation

However, there are other problems with the ILOs, and these problems are related to the motivation of the students. As remarked by Biggs and Tang (2007, p. 23), factors that encourage a surface approach to learning include:

- An intention only to achieve a minimal pass. Such may arise from a "meal ticket" view of university or from a requirement to take a subject irrelevant to the student's programme.
- Assessing for independent facts, inevitably the case when using short-answer and multiple-choice tests.

It is not difficult to argue that algebra is an important tool to learn for the biochemistry students. However, the present ILO does not argue at all. There is *no* intention in the ILO to highlight the relevance of algebra as an important tool for the biochemist. The highly operational goals of the ILO, along with the assessment in the form of multiple-choice tests, will without doubt cause many a student to turn to surface learning – with the intention to achieve a minimal pass, as the content apparently has little to do with the remaining biochemistry programme.

Alignment of ILO and TLAs

The teaching-learning activities of MatIntro are quite diverse. There are lectures (210 minutes a week), classroom teaching (180 minutes a week), computer exercises (80 minutes a week) and independent work with teaching assistance (90 minutes a week). There are, in my opinion, a lot of resources and time available for TLAs. The question is whether these resources are used in an optimal way to stimulate learning.

The computer exercises encourage active students, and most of the exercises require a good understanding of the software, as well as some understanding of the mathematics. These exercises are also based on group-work. I consider them the best part of the TLAs of the course.

The lectures are carefully prepared, but are seldom activating the students. The classroom teaching is based on end-of-chapter exercises. My usual practice as a class-teacher has been to encourage the students to present the exercises at the blackboard, however often there are only a few students that dare to present. In consequence, I (the teacher) go through the exercises, and the students sit back, more or less passively listening and taking notes.

Another reason for the lack of volunteering students is probably that this type of presentation is not aligned with the assessment. There is no oral examination that would motivate the students to practise presenting at the blackboard.

I think the way that the problem-solving classroom teaching is dealt with is one of the major problems of the present TLAs, and something should be done to engage the students in active, deep learning. Inspired by IUP and KNUD, I wanted it to be different this year - and I have therefore focused on changing aspects of the teaching that would engage the students to become active learners, and that would break the routine in the problem-solving classes.

Restating the didactic contract: moving away from blackboard-centered teaching

At a meeting prior to my first encounter with the students at MatIntro I was advised by my pedagogical and chemistry supervisors to explicitly inform the students how the exercise classes would be conducted, in other words to restate the “didactic contract”; the didactic contract is a term coined to explain the often unspoken contract between teacher and student, that if the student engages in the activities proposed by the teacher, this will lead to learning. When the expected blackboard-centred teaching is reformed towards student-centred activities, the unspoken tradition of classroom teaching is broken, and it becomes important to inform and motivate the students for the new type of activities. Due to administrative circumstances, I only knew the names and e-mail addresses of the students in my class very close to the first encounter with the students, so I had no way of informing the students in advance. However, during the first session, I told the students about my plans for the teaching, and they seemed to be satisfied with that. I also told them that my reform of the teaching was part of my project in KNUD. I will later discuss how this satisfaction for some of the students turned in to a mild frustration during the course.

As a class teacher for the MatIntro students, I am, of course, not in a position where I can change the course structure, nor the topics to be covered. There is also a mandatory set of exercises given by the course organizers. I therefore have a (very) limited amount of freedom to change the classroom teaching, and I have chosen to focus on, and experiment with, aspects of the teaching that are relatively straightforward to implement and evaluate. These “new” TLAs are not specifically designed for mathematics, and could probably be used in all kinds of problem-solving classroom teaching. The limited flexibility imposed by being a small part of a large course is also a very common situation for most exercise-class teachers.

Each of the experiments was used a few times during the nine weeks that the course was running. Below, I will present the background and motivation for the experiments; how they were actually conducted and I will try to discuss and evaluate them. Notice that most of my evaluation is based on either direct observation and discussion with the students, or by asking rather open questions that the students have answered on yellow post-it notes. Due to time limitations, I have purposely not made a more formal in-depth questionnaire, but I hope to demonstrate below that my approach has been a quite successful way to interact with the students.

Active learning and variation

The activities that I have tested are all meant to encourage deep learning and to break the monotony of the traditional problem-solving class. As noted by Biggs & Tang (2007), breaks and changes in the activities every fifteen minutes or so are desirable. Few can keep their concentration for longer.

Quick evaluation using post-it notes

The success of the TLAs can be evaluated in different ways. A natural way is to try to sense the atmosphere in the classroom – are the students engaged? Sometimes, it can be fruitful to evaluate the success in a more formal way. On the other hand, time (mine, as well as the students) did not allow me to make a large, formal survey for the students to fill out – this would easily take another 30 minutes of precious maths exercise time. Instead, I chose to write a question on the blackboard, and the students had a few minutes to fill out a yellow post-it note with their answer. I could then analyze the answers later, and report back to the class.

In contrast to other quick ways of evaluating the teaching (like asking students individually in a break) this method sends the signal that the teacher is taking the students’ opinion seriously. It also allows everyone to be heard. Of course, it is important to follow up on the evaluation, and I did this, first of all, by telling the students about the results of the survey, and also by trying to change the teaching according to the critique raised by the students, as I will report below. During the course, problems arose because a group of students felt that we were moving too slowly, or did not discuss all the exercises. As a second part of this report, I have focused on how I have tried to reflect and respond to this problem.

First part: New teaching-learning activities in the exercise classroom

The following TLAs were tried during the course, mixed with more traditional blackboard-centred teaching.

ConcepTests and multiple-choice exam questions

Background

Eric Mazur (1997) and others have demonstrated how simple conceptual tests can engage the students in the lecture hall. The tests are often anonymous, because this allows the students to respond more freely – they are not afraid of giving the wrong answer. The tests are multiple choice, they are clearly worded, and cannot be solved using equations. The purpose is twofold: It allows the teacher to evaluate the students' understanding, but most important, the tests are used to activate the students, because they have to think, and because they are encouraged to discuss the answers with their fellow students, thereby stimulating peer-to-peer learning.

This type of TLA is in good alignment with the MatIntro course assessment, because it is based on multiple-choice questions. In fact, I found that some of the multiple-choice exam questions from previous years could be used for this type of activity (i.e., those that did not demand long computations). Furthermore, I used questions taken from a collection available from a project called 'GoodQuestions' (Department of Mathematics, Cornell University, USA; 2005).

Execution

I found that rather quick 'probing' questions were the best choice as a supplement to the deep and rather difficult exercises which were part of the mandatory weekly programme given by the course administrators in the course. An example is given in the figure 9.2.

> **Probing question:**
> Is the following statement true or false:
> At some point during my life, my height (in decimeter) was exactly the same as my weight (in kilograms).

Fig. 9.2. Probing question.

This question cannot be answered using equations. It draws on basic calculus concepts, namely the properties of continuous functions, such as the completeness of real numbers and the intermediate value problem.

The answer is "true", if we consider my height and weight as continuous functions of my age; as a newborn, my height (or length) was about 0.5 m, while my weight was 3 kg, while now my height is about 1.9 m and my weight 80 kg. Somewhere along my lifeline, the weight and height curves must have crossed, *if the curves are continuous.* So the discussion with the students of course continued: Do we grow continuously? In the mindset of a biochemist this is not a trivial question – perhaps we grow one molecule at a time?

Evaluation

I found this type of activity stimulating and rewarding. The students became more active, and they began to discuss with their peers as well as with the teacher. Another important bonus is that the students got a feeling for the level of their peers. This is rewarding, because normally many students can get the feeling that everyone else understands - and therefore they will hesitate to expose their own lack of understanding.

This activity requires some way of displaying the question and the possible answers. In the case of the question given above, it was easily written on the blackboard. But in many other cases, an overhead projector or similar is advisable because it can take a long time to write on the blackboard.

Often, this type of activity uses an electronic answering system (like in the television quiz *Who Wants to be a Millionaire*). I did not have such a system. Students raised their hands when they agreed – often I chose to use questions with only two possible answers. Of course, this is not optimal, because some students might not want to expose their (lack of) knowledge, and will respond according to the majority. However, the most important part of this exercise is to initiate active learning and peer discussion – the students' immediate answers are of secondary importance, but can be used in order to probe whether further discussion is necessary to increase understanding.

Because some of the questions were taken directly from the previous year's multiple-choice exam there was an extra motivational factor for the students; there was an extremely close alignment between the TLA and the assessment.

Cooperative learning: Circle the Sage

Background

Because Danish legislation prohibits group-based assessment, an important motivational tool for implementing group-based learning processes has been removed. Prior to the change in legislation, MatIntro had mandatory group-based hand-in exercises. I have tried to come up with ways to re-implement cooperative learning activities in MatIntro.

One very popular teaching strategy at the primary school level is the so-called *cooperative learning* method. Some writers use the term cooperative learning in a very broad sense, which would include the learning activity "group work". In a Danish context this often means that a group of students have been given a common assignment, but they have been given no instructions about how the group should work together. At the other end of the spectrum, the term *cooperative learning* is used to signify a very structured type of TLA, where each individual member of a group has different and very explicit roles. This method has especially been promoted in Danish primary schools by Spencer Kagan, who has written a book and some teaching material with different TLAs (Kagan; 1994).

I decided to try out one of these procedures, and my choice fell upon the exercise called "Circle the sage". This procedure was chosen because it is rather easy to explain to the students and does not require a lot of reorganization of the students (and furniture!) in the classroom.

As the name implies, students who have mastered some specific area are "sages", and the other students can then ask these sages questions.

Basically, the sages are co-teachers in the given exercise. This procedure has several benefits compared with a traditional teacher-centred activity. First and foremost, the number of teachers is multiplied with the number of sages. The sages are socially as well as mentally on the same level as the other students, and they may be able to explain the topic in a down-to-earth manner: They know where the pitfalls are. The sages, who will gain little from a mere repetition of a topic they have already understood, will have the opportunity to sharpen their understanding by being forced to explain it to fellow students. Weaker students can often feel exposed by asking the teacher "trivial" questions, but would probably have less trouble asking a fellow student.

Problems

The students may not actually be explaining the material correctly. Also, the topic chosen should be considered carefully. A topic that is too diffuse topic might lead to uncertain sages and frustrated students.

Evaluation

I have only tried this method once, as I found it difficult to find topics that were sufficiently "closed" for the sages to feel confident.

The process is rather time-consuming, because there will be some people who have to move around in the crowded classroom. It also creates a lot of noise because all the groups are discussing at the same time. I think the students were quite satisfied, however I would like more physical space next time I have to do this exercise. Positive side-effects of this exercise are that the teacher removes him- or herself from the centre of attention and into an observer role. Furthermore, the activity can form an important break from blackboard-centred activities. The topic covered during the "circle the sage" activity was unfortunately not part of this year's multiple-choice exam, so I do not have a more formal way of evaluating the success of this activity. I think this procedure could be evolved further, but I would like to have a way to recruit sages so that it is not always the same group of students that are the experts.

Groups presenting at the blackboard: "Group efficacy"

Background

From previous MatIntro classes, I knew that it can be very difficult to persuade students to present exercises at the blackboard. They want to be sure that they have done the exercise correctly before they expose their knowledge in front of their fellow students. Often, I have observed that only three or four students want to go to the blackboard out of a class of thirty students. I wanted to change this for the benefit of all the students. There is no doubt that presenting results to others sharpens the understanding of the topic. Activating the students, and creating the atmosphere that it is all right to "expose your brain" at the blackboard can be important through the whole course – and further on.

Why will the students not go to the blackboard? Partly because they are not confident in themselves. In order to improve their mathematical learning confidence – or "efficacy/capability beliefs" to use the vocabulary of Bob Evans – I chose to invite the students in groups. My idea is that when a whole group of students is responsible for a presentation, this should increase the efficacy of the individual members of the group. Another reason for students hesitating to go to the blackboard is that there is no oral exam, and thus no impetus from assessment. However, this last aspect was out of my control, other than the general "social assessment" from the fellow students and teacher: We expect all participants to make a contribution to the learning activities.

Execution

In the pre-class preparation time, groups of students were told to prepare different problem-solving exercises, and they were told to present their exercise as a group. Of course, only one or at most two students would actually speak up and write on the blackboard, but the rest of the group was present next to the blackboard – ready to back them up if there were questions that the presenters could not answer.

Evaluation

This idea proved to be quite as expected – the students were happy and enthusiastic, and told me that they were more confident when a whole group was presenting.

However, there is a drawback. Normally, if I have the impression that the students have understood the topic, I would skip the rest of the exercises and carry on to a new topic with other exercises. That flexibility is lost here, because the presentation is delegated to the students, and because there is an implicit promise that all students should present their prepared exercise.

I realize that we used a lot of time for this exercise. Perhaps this method should only be used a few times in each course, as it is really very time demanding. Alternatively I will have to think of another way to shorten the exercise if it appears to be superfluous because the students have understood the topic.

Buzz meetings – Two minutes of peer-to-peer discussion

Background

An easy way to get some variation in the teaching is to let the students discuss a problem in pairs. Discussing a problem peer-to-peer allows the students to verbalize and accentuate their understanding, and provokes the students to move away from a surface-learning approach.

Implementation

This activity was used from time to time during the course on an ad-hoc basis, as problems arose in the exercises, especially when I had the impression that the explanation I provided was inadequate for the students.

Evaluation

As the students became comfortable with the approach, it became faster and easier to switch back and forth from the blackboard-centred teaching. Of the different activities discussed here, this activity was the easiest to implement. One drawback is that it is difficult for the teacher to evaluate the students' gain. A follow-up exercise could be a way to provide formative assessment, however, this is not always easy to find on-the-fly.

I really liked the small breaks that this type of activity gave, as it gave me time to think about the next TLA.

Context

Background

My first post-it note question for the students was given on the first day of the course. The question was: *What would you like to bring with you from the MatIntro course?* All students answered, and the vast majority indicated that they wanted to learn how mathematics can be used in biochemical applications. A minority (around 10%) indicated that they simply wanted to pass the course. The responses are quite as I would expect; most students are very enthusiastic and have high expectations as they begin their studies. Of course, I would like the students to keep this enthusiasm, and one way to do this is to introduce some myself.

In the MatIntro course a few of the hand-in exercises have a chemical or biochemical context. However, to make the exercises manageable for the students, the biochemical content has been simplified and diminished to a degree where the exercise can hardly be said to help the students understand how mathematics can be used in biochemistry.

The biochemistry study plan is of no help for defining topics where mathematics could be relevant for biochemists, as mathematics is hardly mentioned.

To give at least some contextualization, a few times I chose to use ten minutes to present some recent biochemical research that involved a lot of mathematics. One was a presentation of the 2009 Nobel prize winners in chemistry, who elucidated the structure of the ribosome – the molecular machinery for decoding DNA. This type of activity, of course, does not activate the students immediately – but I hope it increased their general motivation for doing mathematics.

Evaluation

Each class has a spokesman who speaks for the class at a meeting with the course organizers. Through this meeting I learned that the students liked this particular contextualization aspect of the classes very much. However, given the very tight schedule of the course, I will have to consider whether the contextualization can be implemented as part of actual exercises. Again, time issues prevented me from using more of this type of activity.

Second part: Midway evaluation, related to the problems of the teaching level or a *backwash* problem?

The student evaluation of MatIntro (after about four weeks course) presented via the spokesmen as mentioned above, indicated that my teaching level was too low, and that I was spending too much time helping math students with weak maths capabilities. Perhaps my "experiments" were also taking more time than some students would find beneficial.

However, my impression is that it is often the best students who raise their voice in these matters, and I had the suspicion that parts of the class were satisfied with the level of the teaching. The students less confident with math are also often less confident when it comes to speaking out with their opinion.

Inspired by the quick survey I had used in the first lectures, I again posed a single question: *How do you find the level of the teaching? Should it be higher, lower or just the same?*

Out of the thirty students in my class, I received twenty-two answers on post-it notes. They showed that eleven students considered the level to be right, one thought it was too high, while ten students would like me to raise the level – many of these answers indicated that I should basically just speed up, which would ensure that we could get through more exercises. Admittedly, there were exercises that I would have liked to do, and we had not had the time. I felt that I would have to find a way to speed up, while still answering the questions posed by the "weaker" students. My choice, which was explicitly stated to the class, was to skip some of the easier exercises, so that we only looked at a few easy exercises, and thereby had more time for the difficult ones. This seemed to satisfy most of the class.

Backwash

I must admit that I used fewer experimental TLAs in the last weeks of the course. After the first multiple-choice test (in week 4 of the course), five to ten students were in a situation where they might not pass the course, unless they achieved a good score in the second test. This is the normal situation. Actually, my class had the highest mean score of the four biochemistry MatIntro classes (about 10% higher than the rest); whether this is significant is an open question, however, it seems to indicate that the new activating TLAs had a good influence on students' performance, even in the multiple-choice test.

Given their bad marks, most students were eager to discuss as many previous exam questions as possible. What I experienced was, I believe, a *backwash* effect; while teachers see the ILO as the central pillar in an aligned teaching system, the students will always see the assessment as what defines the actual curriculum (Biggs & Tang; 2007, p. 169). Since the most important part of the assessment is the multiple-choice test, this was the focus of the students. The didactic contract that I set up during the first day of the course was falling apart as we reached beyond the first multiple-choice test. In the students' eyes, the focus moved entirely towards the second test, especially for the weaker students. It is not trivial to propose new TLAs that can be well aligned with a multiple-choice assessment, and that still encourage a deep-learning approach!

This was probably my greatest challenge during the course – that the students have very different maths capabilities, and that their minds were focused on the multiple-choice test. The large differences in math capabilities seem to be more significant for the biochemistry students than for other groups of students:

In the histograms in figure 9.3, I compare the total number of points that the students achieved in the multiple-choice exam. The number of points ranges from 0 to 20. Evidently, the biochemistry students generally get fewer points than the maths and physics students, and the spread of points is larger. Notice that while the biochem histogram is approximately bell shaped, the maths/physics histogram is skewed towards the high grades.

One interpretation of the biochem histogram could be that there is a group of biochem students that struggle, and they will be satisfied with passing the course, while another group of biochem students will try to get a high grade. In contrast, for the maths/physics students, the majority of students will study to get a high grade.

Another interpretation is that the histograms demonstrate that the present course is better suited to the maths/physics students than to the biochemists. As argued by Biggs and Tang (2007, p. 171f), a bell-shaped curve of grades is not desirable: If the teaching and learning is good, we should have every reason *not* to expect a bell-shaped curve at university level, both because the students are not randomly selected, and because we should be able to make most of the students turn to deep learning instead of surface learning.

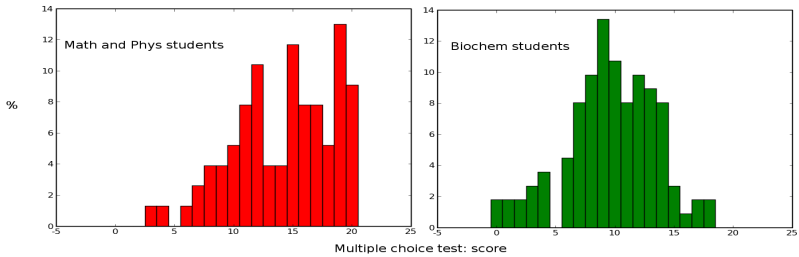


Fig. 9.3. Multiple-choice test: scores

Looking ahead: Re-organizing the problem-solving classes

The evident success of MatIntro in bringing much higher pass rates makes it difficult to argue for a total restructure of the course. If I had the power, I would basically advocate splitting the course into fraction one for the maths/phys students and another for the chem/biochem students. However, a smaller re-organization of the problem-solving classes might solve some of the problems related to very large differences in maths capabilities of the biochemistry students.

The situation reminds me of an approach that was presented during the KNUD course, and used in an undergraduate-level physics course at the University of Copenhagen. In that case the teaching in three parallel exercise classes varied according to the level of preparation that the students had. The students could then choose on a day-to-day basis which class to attend, depending on how well they understood the topic, and how much they had prepared for the exercises:

1. One classroom for the students that had not prepared at all, or could not solve any of the problems.
2. One for the students who had tried to go through the exercises, but could not do it all (or did not have the time).
3. One for the students who had done all the exercises, and would like to discuss the fine details of the exercises, or perhaps look at advanced exercises.

Obviously, such an approach requires that the number of students is sufficiently high to have three parallel classes. With more than 600 students this is not a problem for MatIntro, not even if we consider the biochemistry students only, which totals about 120 students in four classes.

Such differentiation would solve the problems with students getting frustrated because the level is not appropriate for them. When I introduced this idea to my fellow teachers at the MatIntro course, they raised two questions:

1. *Administration:* It will be a nightmare in terms of administration - what if all the students choose to go to the same classroom? What about the hand-in exercises?
2. *Inspiration:* Do the weaker students not need to be inspired by the strong students? If they do not experience how the strong students handle the exercises, how can they improve themselves?

My answer is that implementation of new ideas always require more energy and effort than doing the usual thing – however, in this case I think there are good reasons for trying a new scheme. If the level of the students is different that expected, e.g. that all students arrive well prepared, then the teachers have to adapt e.g. with more classrooms at higher level, and none at low level.

Regarding the inspiration from better students, my experience is that students tend to find study partners that are more or less on level with themselves. Consequently this source of inspiration is probably not much present anyway, unless the classroom TLAs are of the *cooperative learning* type. Furthermore, the students can always move to one of the other classrooms if they want to be inspired at another level – the differentiation is entirely based on the students' own idea about where they think they will learn the most. I will propose this idea as a pilot project for next year's MatIntro course.

Post-course evaluation and conclusion

On the last day of the course, I tried to get some further responses from the students, and I asked them the following question, which was to be answered anonymously on a post-it note:

> *Please give your best suggestion for an improvement in the problem-solving classes.*

Apart from expressing their general satisfaction with the teaching (which I did not ask for), I got the following suggestions for improvements:

1. More student activation/interaction.

2. More emphasis on the necessity to prepare at home before the classes.
3. More exam questions (at least one each class day).
4. More strict use of the blackboard (I apparently have a tendency to mess it up)
5. More cake!

I was surprised by suggestion 1 as my impression was that most students thought there was plenty of activation. At least this suggestion will encourage me to try even more ideas next year. Suggestion 2 is something I have not considered very much – in my standard version of the (unspoken) didactic contract, preparing at home is mandatory. But I will emphasize the need to prepare before class next year, or even design small assignments that will ensure they have prepared. Suggestion 3 was expected: Again, the "backwash" effect. Suggestion 4 was also expected, and the use of the blackboard is something I am constantly struggling with. Suggestion 5 is of course not serious, since I think we had about as much cake as anyone can eat. See below for further comments on the quality and quantity of cake.

My class of students ended with a mean final score very similar to the other biochemistry classes, and quite a bit lower than the scores for the chemistry, physics and maths students.

There are other ways to measure success than the final grading, and I can say that I have personally enjoyed the helpful, hard-working and enthusiastic atmosphere that I believe was partly created as a product of the student-centred TLAs. That the students also enjoyed and contributed tremendously to this atmosphere is also reflected in the number of home-made cakes from students that we enjoyed during the course. I volunteered to bring cake the last day of the course. I hope my teaching abilities are better than my cake was.

10

How Students Evaluate the Laboratory Exercises in Pharmaceutical Physical Chemistry

Anan Yaghmur

Department of Pharmaceutics and Analytical Chemistry, FARMA, University of Copenhagen

Introduction

I am taking part in teaching the course of Pharmaceutical Physical Chemistry course at the Faculty of Pharmaceutical Sciences (FARMA). In addition to teaching pure physical chemistry principles at the undergraduate level, the course aims to provide insight and to develop deeper understanding in different topics that are important for the students to learn due to their pharmaceutical relevance. It should be pointed out that the physical chemistry course is a prerequisite for admission to different interdisciplinary courses on the advanced level in the faculty. The Pharmaceutical Physical Chemistry course consists of large class lectures, small exercise classes and a laboratory course. In this project, I will focus only on evaluating the laboratory course of the Pharmaceutical Physical Chemistry (see below for a short description of this course). Here, my main concern is how to lead the students to be efficiently engaged (the required active participation) and to fully understand the laboratory exercises. In general, there are different factors (Hahn & Polik; 2004) that may affect the overall degree of success in teaching physical chemistry. I believe that the following four issues are among the most important factors that we need to consider as teachers in pharmaceutical physical chemistry in order to help students to achieve the intended learning outcomes of the course and to obtain a higher degree of success: (1) the low preparation level of some students for the laboratory exercises, (2) the lack of scientific interest to learn, (3) the difficulties in understanding the basic principles, and (4) the difficulties in solving physical chemistry problems in the reports, which are typically described with mathematical expressions.

My main purpose is to evaluate and to understand students' perceptions of the learning difficulties, to learn from their proposed improvements, and to avoid obstacles or difficulties when performing the exercises and also when writing the reports.

The following main questions guided the present report:

1. Do we need to improve the written text of the procedures of the laboratory exercises and the underlying theory? Are there any points that are not clear in these two parts?
2. How do the students evaluate the provided aids (the theoretical background, the experimental procedures, and the mentioned relevant chapters of their textbook)?
3. What part of the exercises does the students like/dislike?
4. How do the students evaluate the safety issues in the laboratory?
5. Are there any general recommendations from the students to improve the course?

Details of the laboratory course

Before describing laboratory course in detail, I will briefly present the three following main teaching activities in the Pharmaceutical Physical Chemistry course: large class lecturing, small class teaching on exercises, and the laboratory course. The relationship between these activities and the written exam is well established.

Large class teaching

The 45-minute lecture course deals with various topics including thermodynamics, electrolyte and non-electrolyte solutions, states of matter, chemical kinetics etc. Here, it is important to mention that the lectures are designed to make a link between the concepts being taught and the relevant laboratory exercises and the pharmaceutical relevance.

Small exercises class

Different chemical behaviours are explained by mathematical expressions and learning them is very important tool for predicting students' performance in solving problems. The students have the opportunity to work in small teams for problem-solving on different topics described in the large class lectures. The students interact more with the teacher than is possible in the large class.

The laboratory exercises: Active participation and reports

In the laboratory course, the students work on exercises in pairs or in a few cases, groups of three. The students carry out twelve different practical exercises in major topics of physical chemistry that were presented in the lectures. The course is structured to have eleven meetings in total during autumn to perform the exercises, which are designed to ensure active participation and direct student-teacher interaction, and to develop students' skills in performing the experiments by using different techniques as well as in reporting the experimental data obtained. Active participation means that all experimental exercises are satisfactorily performed within a four-hour period, and the reports with data analysis and answers of relevant questions are submitted at time and must be approved by the teacher. Each group is expected to complete the lab report which is due at the beginning of the next laboratory period. As the teacher, I circulate among the students while they perform the exercises to discuss their experimental data and to check their level of understanding level of these exercises by asking related questions. This leads in many cases to me asking the students to report on their experience while performing the exercises and helping if there are any problems or any points which are not clear.

Questionnaire

In order to give the students the opportunity to evaluate the practical exercises in the laboratory course anonymously, I prepared a short questionnaire consisting of ten multiple-choice questions with eight of them rated on a 5-point scale and six additional free-response questions (the questionnaire is given in Appendix A). The last two narrative questions were on evaluating the overall course. It was important to formulate the questions to be specific to the lab exercises. The questionnaire was reviewed by other teachers who were involved in this course and also by our KNUD teacher Camilla Østerberg Rump. The contribution of both Camilla and my colleagues was very helpful in shaping the final form of the written questions. Among other things, this questionnaire was designed to shed light on the difficulties/obstacles on learning at the lab course and to focus on how to improve the learning environment after analyzing the students' answers and their comments/suggestions. Some of the specific questions were related to the written reports; therefore, it was important to ask the small groups (two or three students per group) to complete the questionnaires cooperatively (team reflection) after finishing their reports. The participation of the students in this project was voluntary. The selection of the five laboratory exercises was based on either their pharmaceutical relevance or the observed degree of difficulty students experienced in writing their reports. These lab exercises cover different physical chemistry topics including colligative properties, calculation of partition (P) and distribution coefficients (D), electrochemical processes, specific acid and specific base catalysis, and diffusion process.

We evaluated the responses to 75 questionnaires. In this project, we focus only on discussing the average responses given to the ten multiple-choice questions for the five laboratory exercises and the summary of responses of the six additional free-response questions. It is worth mentioning that the responses to every specific exercise will be discussed with the teachers of the course. In general, the students' responses on the different exercises were similar. Therefore, it is worth reporting here on the data analysis of the average responses given to the five exercises.

Results and discussion

The students' responses to the multiple-choice questions

Pre-Laboratory Preparation: Of the 75 responses, 60% of the students spent only 15-30 minutes on the pre-laboratory preparation including reading the experimental procedure with specific instructions on how to operate each instrument and the theoretical background (Fig. 10.1a), while 33% spent 30-60 minutes. Such a low preparation level is remarkable and surprising, especially in that 4% did not prepare at all, and only 3% spent 60-120 minutes on the pre-laboratory preparation. The efficiency of this preparation within the mentioned time periods is also an important issue but it is a difficult task to evaluate and therefore it was not tackled in this project. As presented in figure 10.1b, 31% of the students felt that their degree of preparation for performing the exercises was good, and 47% were neutral. 22% indicated either a poor or fair degree of preparation. Only 1% of the students felt that they were well-prepared. Here, the lack of motivation of some students could also significantly affect the preparation level. It was reported that the lack of motivation in physical chemistry courses could be attributed to the abstract nature of concepts in these courses and the high level of mathematical knowledge required (Hahn & Polik; 2004; Sözbilir; 2004; Tsaparlis & Gorezi; 2005). Pre-laboratory preparation is highly important for the deep understanding of the laboratory exercises (Johnstone & Al-Shuaili; 2001; Rollnick et al.; 2001). As Johnstone and Al-Shuaili (2001) observe:

> "investigation is very knowledge dependent and cannot take place in a knowledge vacuum".

Clearly, there is a need to increase the level of students' preparedness to ensure a higher degree of understanding and active engagement in the laboratory. Rollnick et al. (2001) reported on the importance of adequate student preparation for the laboratory and discussed the different degrees of preparedness found between prepared and less prepared students. It was also easy to distinguish between these two different groups in this laboratory course. Three aspects of the pre-laboratory preparation which are helpful in achieving the successful completion of a practical were identified (Rollnick et al.; 2001):

1. A "bird's eye view" of the practical. This can be achieved by asking the students to prepare a half-page synopsis of their lab exercises, which includes the aim of the exercise, background and procedural information including the important experimental elements such as specific reactions, relations, or substances.
2. Prerequisite knowledge required to perform the exercises. This can be achieved by including a set of pre-laboratory questions. In our course, there are few written questions on every exercise included in the laboratory manual. To increase the pre-preparation level, I suggest preparing a few additional multiple-choice questions that the students have to complete before performing the exercises. There is need also to have more pre-laboratory discussions with the students.
3. A detailed understanding of the experimental steps. Asking the students to prepare a flow diagram is one method that can be used.

These aspects and the proposed suggestions will be discussed with other teachers of this course to see what can be changed to increase the degree of preparation. In particular, after the analysis of the students' responses (Fig.

10.1(c)) to the question of how they evaluate their degree of understanding the written laboratory manual before the exercises, only 25% felt that their degree of understanding was good whereas 50% felt that the degree is either poor (15%) or fair (35%). According to Rollnick et al. (2001):

> "It is the next tier down that obligatory preparation benefits most those who willing in spirit but poorly organized or those who would skip preparation because of the load of other academic work".

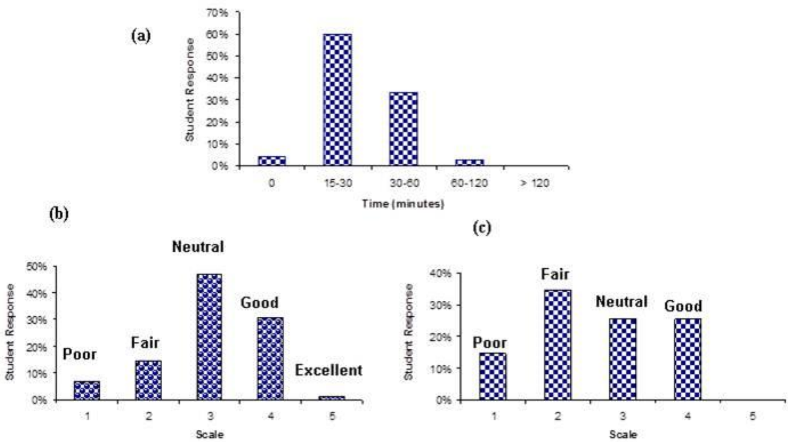


Fig. 10.1. The students' responses to how much time they spent on the pre-laboratory preparation (a), the degree of their preparation (b), and their understanding of the written laboratory manual (c).

Writing the report

The time needed to complete the reports and to answer the included questions is dependent, among other factors, on the number of tasks involved, the questions and the degree of difficulty in understanding the experimental exercise. Among students, this time would vary from group to group. For instance, it took relatively more time to complete the reports for the two experimental exercises on the colligative properties and the electrochemical processes, which some students find relatively difficult and which demand more time to answer the questions related to the experimental data. Also, it generally takes more time for less well prepared students to complete their reports. In general, the approval of their reports by the teacher also requires more time than for well prepared students. As indicated from the students' responses, most students completed their five reports within 1-3 (36% of the students) or 3-6 hours (31%). 22% completed their reports within 6-9 hours and 7% needed more than 9 hours (Fig. 10.2a).

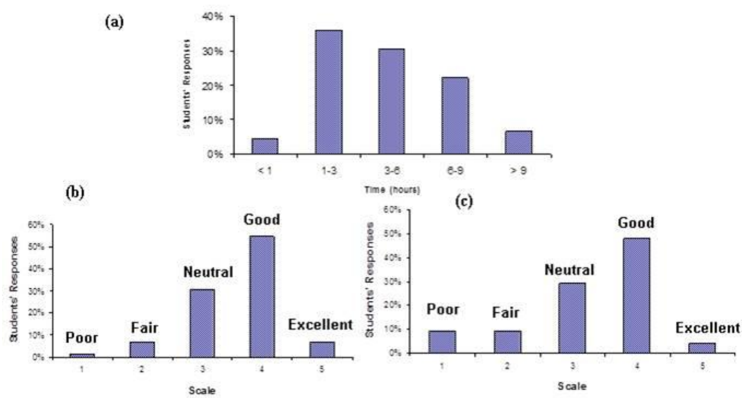


Fig. 10.2. The students' responses to how much time they spent after the exercise on writing the report (a), the degree of understanding the exercise after writing the report (b), and their rate to the provided aids.

The students' response to the question on the degree of understanding the exercises after writing the report was positive and encouraging (Fig. 10.2b). 62% of the students felt that their understanding was good (55%) or excellent (7%), although some of them had a neutral response (31%). Figure 10.2c and 10.2b indicates that the laboratory experience is very effective in teaching physical chemistry. The presented data indicated a significant improvement in understanding the topics after performing exercises and writing their reports due to the active student-student and student-teacher interactions and also due to the involvement in the practical activities. I believe that increasing the level of the pre-laboratory preparation by considering the suggested changes is an important step that can be helpful in improving to an even higher level of understanding physical chemistry in the laboratory. The provided aids including the laboratory manual (the theoretical background and the experimental procedure) and the mentioned chapters of the used textbook in this manual were rated 4 or 5 from 5 by 52% of the students (Fig. 10.2c). The written theoretical background and the experimental procedure in the laboratory manual were rated 4 or 5 by 69% and 78%, respectively (Fig. 10.3). Some students indicated that it was hard for them to understand the written theoretical background in some of these exercises. The main reason was performing the experiments before learning the relevant topic in the lectures (the lectures and the laboratory course are offered in the same semester). There were also some students who felt that the mentioned chapters of the textbook were not very helpful in understanding and writing the reports of some of the exercises. Here, the students should take advantage of the direct student-teacher interactions in the laboratory and the pre-laboratory discussions to improve the understanding of the relevant topics. But such interaction is not efficient when some students are not motivated or not well-prepared to perform the experiments.

Subject	Scale of Rating				
	1	2	3	4	5
The theoretical background	7%	7%	17%	57%	12%
The experimental procedure	1%	5%	12%	55%	23%
The safety at lab	1%	5%	9%	31%	53%
The overall learning outcome	4%	11%	17%	64%	4%

Fig. 10.3. Learning outcome from the exercises.

Most of the students highly agreed (53%) or agreed (31%) that they did not experience any safety issue during performing the exercises (Fig. 10.3). This was very positive evaluation of the safety of the laboratory.

The overall learning outcome

The learning outcome from the exercises was rated 4 or 5 by 68% of the students (Fig. 10.3). This indicates that the practical laboratory work is efficient tool in learning physical chemistry. The students have a good opportunity to examine the presented experiments, to develop their awareness on the frequently used methods when performing the experiments and how to use them, and to comprehend the basics of different physical chemistry topics. The positive evaluation of their laboratory experience is described below in detail.

The evaluation of the free-response questions

The free-response answers of the students to questions 11-13 including the most positive and most negative aspects of the laboratory exercises, are summarized in Figure 10.4. Among the most positive aspects, the students mentioned the important role of teachers in helping with both the practical exercises and the reports. We recall here the research study of Herrington and Nakhleh (2003) reporting on how the chemistry laboratory instruction, which is different from that in the classroom instruction, is important to consider for developing successful and effective teaching of chemistry in the laboratory. The mentioned negative aspects were mainly related to difficulties in understanding the exercises and writing the reports. There were also various suggestions from students (answers to question 14) for changes that could be made to improve some exercises. To avoid repetition, these suggestions are summarized below with other changes suggested by the students for improving the overall course. In general, most students were very satisfied with the course. As an example of an answer to question 15, one student group mentioned:

> “Overordnet er kurset rigtig godt. Vi får meget ud at lave rapporterne. Der har dog været nogle af øvelserne, hvor vi har forstået teori bag under udførelsen af øvelse. Rapporterne har hjulpet på forståelsen.”

The students’ suggestions for improving the overall laboratory course

The students mentioned a number of improvements that might be made. The main given suggestions were:

1. To improve the written theoretical part in the laboratory manual for some exercises. Some students commented that they felt that this part is difficult to understand and/or included irrelevant information. It was suggested to write it in a simple manner.
2. To improve the written experimental procedure in a few exercises. Some students suggested writing this part in more detail and writing it in a simple manner with short and simple sentences.

What were the most positive aspects?	
1. Efficient for learning and understanding the theory given in the lectures 2. Developing practical skills in performing experiments and using techniques 3. The exercises are linked to the written exams. Understanding them leads to good performance in the exam 4. Good supervision from the teachers at the lab 5. Good technical support from the technicians 6. The pharmaceutical relevance of some exercises 7. Learning how for first time to use different techniques	8. Exercises which easy to perform and to understand 9. Reports of some exercises that were easy to write. 10. Team work in the students' groups 11. Safe exercises 12. Enjoyable experience when the exercises were well understood 13. The detailed experimental procedures of some exercises 14. The overall knowledge gained when combining the exercise with the written report 15. The techniques and the substances were ready to use

What were the most negative aspects?	
The theoretical part: 1. Difficulties in understanding the theoretical part 2. Not understanding the exercise and the obtained results 3. Performing the exercise before learning the theory 4. Difficulties in understanding the mathematical expressions in the theoretical part 5. Feeling in few exercises that the theoretical part includes points that were not relevant to the exercise and the report 6. Feeling that the theoretical part is not helpful in answering the questions and the report **The exercises:** 1. The need for more detailed experimental procedure in few exercises 2. Feeling that the pharmaceutical relevance is missing in few exercises 3. Some students disliked that one of these exercises is very easy and fast	4. Difficulties in using the techniques 5. Technical problems during the exercise 6. Difficult time at the lab without pre-laboratory preparation 7. Exercises that involve many experimental parts 8. Consuming long time in performing some exercises 9. Long waiting time in some exercises 10. Consuming time in few exercises for both cleaning and setting up 11. Not understanding if the obtained results were acceptable or not. 12. Not sufficient information in the first day of the course 13. Having only one teachers at the laboratory 14. Not enjoyable one exercise or more for some students **The report:** 1. Difficulties in writing some reports 2. Reports that include many and/or difficult questions 3. Consuming long time in writing some reports

Fig. 10.4. Summary of students' free response answer

3. To include more images/cartoons in the laboratory manual. These cartoons help the students to understand the exercise and the experimental procedure during their pre-laboratory preparation.
4. To insert more examples of the pharmaceutical relevance of the exercises. Some students felt that few exercises are irrelevant to their pharmaceutical education. We need to consider in more depth the need of highlighting the pharmaceutical relevance of these exercises.
5. To improve the written questions for some reports. Some students felt also that there were too many questions in a few exercises.
6. Some students commented that it would be helpful to consider having more than one teacher in the course. The students felt that they did not need to wait so long for having support in the first two weeks when two teachers were in the laboratory. However, it is difficult to have more than one teacher due to the limited financial and teaching resources. In addition, the students have to wait only a few minutes to get the required support from the teacher.

Conclusions

The evaluation of the students' responses showed that the majority of them were satisfied with the course. Their responses indicated that they felt that the laboratory course is an effective learning tool. This is an indication in itself of a successful course. One important finding was the low level of pre-laboratory preparation among students, meaning that only a few students were ready to perform the exercises. In an attempt to address this problem, we suggested few changes that could be adopted the course. In addition, the students offered a number of suggestions for improving the laboratory work. These suggestions and the mentioned changes will be discussed with other teachers of the course to check what we can do to improve the learning environment.

Acknowledgments

I would like to thank the members of the teaching team of the course: Jesper Østergaard (the course coordinator), Henrik Jensen, and Susan Weng Larsen for their valuable suggestions and comments. In addition, I would like to thank Camilla Østerberg Rump for improving the questionnaire. I also thank the students who took part in this project.

A Questionnaires About the Laboratory Exercises

Questionnaire about the Laboratory Exercises

A22-2: Pharmaceutical Physical Chemistry

The main purpose of this questionnaire: our main goal is to provide you with an excellent learning environment for achieving the intended learning outcomes of this course as described in the following link: http://www.farma.ku.dk/index.php/Farmaceutisk-fysisk-kemi-oeve/6110/0/). In this regard, your feedback will be important to improve these exercises. This questionnaire is designed to provide accounting of how you reflect as student on these exercises and what to do to improve them in order to meet the intended learning outcomes of the course.

Please note that the questions mentioned in the sections I-IV are related to your feedback on the specific exercise and the questions mentioned in the section V are on your overall experience of the laboratory course

I. How did you prepare at home before the laboratory exercise?:

1. How much time did you spend preparing at home before the laboratory exercise? [Minutes]

0
15-30
30-60
60-120
> 120

2. To what degree did you feel prepared and ready for performing the exercise?

Poor	1
Fair	2
Neutral	3
Good	4
Excellent	5

3. To what degree did you feel that you understood the written theoretical background and the experimental procedure before the exercise?

Poor	1
Fair	2
Neutral	3
Good	4
Excellent	5

II. How much effort and time were invested during writing the report?:

4. How much time did you spend after the laboratory exercise on reading the material, analysing data and writing the report altogether? [Hours]

< 1
1-3
3-6
6-9
> 9

5. After having written the report, to what degree do you feel that you understand the exercise?

Poor	1
Fair	2
Neutral	3
Good	4
Excellent	5

6. How do you rate the provided aids (the theoretical background, the experimental procedure, and the mentioned chapters of your textbook) as being of use for writing the report?

Poor	1
Fair	2
Neutral	3
Good	4
Excellent	5

III. Rating Your Laboratory Exercise:

Please circle the number that corresponds to your level of satisfaction* (with the following aspects of your laboratory exercise as follows):

***Please focus on how you find the provided materials (the theoretical background and the experimental procedure) to be particularly important during performing the exercise and reporting on the experimental data and how they affect overall your understanding level.

7. The written theoretical background: I found that the written theoretical background is very helpful in understanding what the exercise was about

Highly agree	5
Agree	4
Neither agree nor disagree	3
Disagree	2
Highly disagree	1

8. The written experimental procedure: I found that the written experimental procedure is very helpful in understanding what the exercise was about

Highly agree	5
Agree	4
Neither agree nor disagree	3
Disagree	2
Highly disagree	1

9. Safety issues in relation to the exercise: I did <u>not</u> experience safety issues during the exercise that had not been addressed in the written experimental procedure

Highly agree	5
Agree	4
Neither agree nor disagree	3
Disagree	2
Highly disagree	1

10. How do you rate your overall learning outcome from the laboratory exercise?

Poor	1
Fair	2
Neutral	3
Good	4
Excellent	5

IV. Narrative Questions on the Laboratory Exercise:

11. What were the most positive aspects of your laboratory exercise? (or what did you like most in your exercise?)
12. What were the most negative aspects of your exercise? (or what did you dislike most in your exercise?)
13. Please give your comments on the laboratory exercise
14. Where do you feel improvements could be made?

V. Narrative Questions on your overall experience of the laboratory course:

15. How do you evaluate the laboratory course? Please mention the reasons for your satisfaction or dissatisfaction?
16. Do you have any suggestions for improving the overall laboratory course?

11

Learning based on students' active participation in transforming theory into practice – as perceived by the students

Annie Høgh

Department of Psychology, SAMF, University of Copenhagen

Introduction

According to the theory of constructivism, learners construct their knowledge with their own activities building on what they already know and understand (Biggs & Tang; 2007, p. 21). Thus, teaching is not a matter of transmitting but of engaging students in active learning.

Last autumn I developed a dialogue-based seminar where I gave lectures part of the time and the students participated in discussions, saw film clips and video case stories and analyzed paper-based cases. However, I had the feeling that the students did not really read the mandatory literature, at least not until after a mid-term exam, and that it affected their participation during class. Sometimes it made it difficult to have an active discussion in class. So, in order to further develop the seminar I wanted to encourage student participation by letting them work in groups preparing presentations of theories and models from the mandatory literature for use in analyzing case stories.

The seminar

The title of the seminar was: *Psychosocial work environment: Conflicts, negative behaviour and bullying in the workplace.* Nineteen students were enrolled in the seminar and they participated in the whole seminar. Most of the students were Danish and some were from Norway or Sweden. Approximately three-quarters of the students attended the class on a weekly basis, at times a little more and at times a little less. I do not think that this is unusual for this type of course.

The course was outlined as a weekly two-hour seminar over twelve weeks between September and December with a mandatory curriculum of 600 pages which was used in class. The literature was mainly scientific articles and book chapters selected to cover the different topics of the seminar. In addition, the students needed to select 600 pages by themselves primarily for use in a synopsis exam. The exam is an oral exam based on a synopsis and includes supervision of the students which takes place in the second half of January.

A general outline of the seminar that was given to the students before they signed up for it:

> At the seminar the concepts of conflicts, negative behaviour and bullying will be illustrated from a work psychological, managerial and relational perspective and by use of theories in these areas. At the seminar we will analyse risk factors/antecedents and consequences of conflicts, negative behaviour and bullying for the individual, the group and the organisation. The seminar will also include a discussion on how you can work with prevention and rehabilitation in connection with these forms of behaviour in organisations. The seminar will include lectures and case analyses and the students are expected to participate actively by giving presentations and participating in exercises (Source: Teaching plan, autumn 2010).

In order to motivate the students into volunteering to give a presentation, I argued that it would be a practical exercise for the exam, where they also have to give a ten-minute presentation. Accordingly, many students volunteered at the first session, two backed out again because they were not able to participate in the session they had chosen for their presentation and they did not want to take up another. The rest I tried to motivate along the way, however there were three students who did not want to do a presentation.

General instructions were given in the first session included that they should present one or two theories from the curriculum of the session that they chose. I also suggested that their presentation should only last approximately ten minutes. I tried to talk with the students in the session before they had their own presentation to make sure they knew what they should do. However, that was not always possible for various reasons.

The inteded learning outcomes (ILOs) were presented at every session and an overall ILO for the whole seminar was outlined in the first session: *the purpose of the seminar is that you acquire knowledge about the* *psychosocial work environment with special focus on what may go wrong between people and the potential consequences that may have for the individual, the work group and the organization as a whole and how it may be prevented*. The session ILOs were also focused on acquiring knowledge and some of them included that the students should be able to analyse a case.

In the first session, the students were asked to write their expectations for the seminar on a piece of paper, which I collected and tried to include when planning the sessions.

The seminar was organized so that every session included either reflections on a problem or a theory and/or case analyses in small (two persons) or bigger (four-five persons) groups based on the theory or models presented.

Evaluation of the seminar

The evaluation was carried out using a semi-structured questionnaire with seven quantitative questions and seven open-ended questions. The questionnaire was given to the students at the end of the seminar; two students filled in the questionnaire at the second to last session and two students were not present at the last session and did not fill in the questionnaire. One of the last two had participated in very few sessions (this student was the only one). The questionnaire also included an evaluation of the expectations that the students were asked to formulate at the start of the seminar.

A qualitative group-based mid-term evaluation was also carried out and the results were used to adapt the teaching of the second part of the seminar.

Results of the evaluation

To the first question: "Will you be able to use what you have learned at the seminar", fourteen students ticked the "to a high degree" box and three students the "to a very high degree" box.

The next question asked whether they had given a presentation; six students had done so together with one other student, five together with two other students, one had done it on her own and five had not given a presentation. A qualitative question asked them to describe how it was to give a presentation. All twelve students who had given a presentation made a comment. Ten students wrote that it was positive, a fine process, fun, a learning experience. One wrote that the articles were exciting and another that (s)he learned from summarizing theory from different articles, to present and discuss in plenum. One noted that it was a different and positive process to work through the texts in a different way than just reading them. One found that it was manageable, which was positive because it motivates one to give a presentation when it does not seem immense. A couple of students wrote that the audience was positive.

On the more negative side, two students indicated that the instructions were not clear enough. One felt that she was cut off by the teacher because they talked about something that was on the agenda for the next session. One found that the teacher asked many difficult questions and hoped that it would not be so at the exam. One felt that it was a learning experience for the presenter but not always so for the listeners. One student experienced a great freedom with regard to expectations and how it was done, which (s)he appreciated but felt that the quality could have been higher if the instructions were more specific with regard to critique of theories, use of PowerPoint etc. Some students just summarized the articles which was not very interesting, I think. It would have been more interesting to find special points, questions of doubt or something else that would have generated a discussion.

The students were also asked about their experience of the other students' presentations. All students made a comment; and thirteen had positive comments: structured and interesting, professional, useful, exciting, relevant, some better than others, everybody was prepared and knew the theory, the PowerPoint presentation was good, nice to hear other students' interpretation of the texts. On the negative side were comments like: different standards, should have been shorter, sometimes too much repetition and a little boring when you had read the text yourself, too bad that not everybody had a presentation, often it was too time consuming, but also nice with variation of the teaching.

The students were also asked what they thought about the format of the seminar in general. There were four response categories between "really good" and "bad"; five students ticked "really good", eight ticked "good" and one ticked the third category "not so good". One ticked in between "really good" and "good" one in between "good" and "not so good".

Fifteen students also wrote comments. They were mostly positive: they liked the variation between lectures, student presentation, reflections and opinions, that there was time to discuss theories and methods, analyzing cases in the form of film clips/videos and written cases, aimed towards use in real life.

The last question asked whether the seminar met their expectations; six students wrote "yes, to a high degree", nine ticked "to some degree" and two ticked "no". Twelve students wrote comments. A few wrote that the atmosphere was good.

Discussion

The evaluation of the seminar shows that the students generally speaking were satisfied with the active form of the seminar and all found that they could use the knowledge that they had acquired during the seminar to a high or very high degree. The seminar exam is after the deadline of this paper, so the level of actual learning will be evaluated later.

According to Mazur (1997) most students tend to read their textbooks too quickly without reflecting on the meaning of what they have just read. Thus, a more participatory way of preparing for class may be a better learning experience. As one of the students commented in the evaluation: it was "a different and positive process to work through the texts in a different way than just reading it".

I do not think that student presentations should be the only activity in the class since the person(s) who learn the most will be the presenters. However, in combination with the other activities, including group analyses of cases whether they were presented in film clips, videos or written cases, it will enhance the learning of the individual student. Still, some students found that it was "nice to hear other students' interpretation of the texts". Thus, you can also learn from other people's interpretation and how they choose to present a text.

Some students found that I as a teacher asked too many difficult questions. According to Brousseau's theory of didactic situations (Christiansen & Olsen; 2006) people learn by relating to specific situations. Such situations may be created through case stories that the students discuss and analyse among themselves. The theory of didactic situations points out that it is important that a "personalization" takes place, for the students to find the teaching meaningful and relevant. Instead of the teacher asking questions in relation to the presentation, deeper knowledge may be attained when the students analyse the cases together with fellow students and present possible problems and discuss them in plenum afterwards. The teacher participates in plenum discussions primarily as the coordinator and leader of the discussion.

Adaptation to an environment – Piaget's basic metaphor about learning (Christiansen & Olsen; 2006) – is important for didactic situations. However, adaptation demands a personalization of the text. An even higher level of personalization would be possible if the students were to discuss their personal experience with the subject to a higher degree, as a couple of students suggested in the evaluation. This would demand a high level of confidence and security in class. I think that this was present in this particular class – some of the students wrote in the evaluation that there was a good climate and atmosphere in class which made it possible for at least some students to talk about their own experiences. This is in line with Brousseau, in so far as he emphasizes social relations and their importance for learning (Christiansen & Olsen; 2006). However, it is also an important task of the teacher to make sure that the reflections on the texts or cases do not move to any great extent from an academic and analytical perspective to a more personal and anecdotal one.

In general, the objectives of the course seemed to be met at least when looking at the evaluation. In this regard, they met the expectations of fifteen out of seventeen students. Whether they actually learned something will be revealed at the exam. Some of the students had hoped for concrete, practical and useful knowledge about the subject and felt that they had achieved that. In future seminars, I will focus the objectives even more on the ability of the students to analyse cases.

The level of activity in the seminar was quite high. Some students were most active in small groups, however, I think that is quite normal and it is therefore important that group work is possible in class. The general level of activity was high, even for this sort of course. The students evaluated their own activity a bit higher than their fellow students did.

In conclusion, I think that introducing the student presentations was a success and I will use this in future seminars of this type. It should not be the only student activity, though, but together with the other activities I think that it worked out well.

12

Group work: A learning barrier?

Alberto Grossi

Department of Food Science, LIFE, University of Copenhagen

Purpose

During Block 1 2010 I was involved for the first time in “Physical and Chemical Changes of Food Quality” in the Department of Food Science, Faculty of Life Sciences. Inspired by “Teaching for Quality Learning at University” (Biggs & Tang; 2007) and by stimulating discussions with pedagogical supervisors and colleagues, I started thinking about how I could design some learning activities that could make group work (GW) the centre of a stimulating and involving learning experience.

In this project, I intended to discuss the use of GW as a teaching tool and to suggest that learning experiences will be more effective if planned in a structured way with teachers taking account of the relationships between group size, interaction type and the nature of the intended learning task.

Introduction

Background

I am a postdoctoral researcher and I was involved as a teacher in “Physical and Chemical Changes of Food Quality”. It is quite common in the Department of Food Science that the responsibility to design and structure the laboratory practicals of a course is assigned to a postdoc or an assistant professor.

I was really positive about the idea of playing a role in the laboratory practicals of this course because I think that practical work is really important in science education for two main reasons: it promotes conceptual and procedural learning. The first accentuates the fact that students are physically and practically involved in some lab activities. During these activities their ability to understand is amplified, moreover, practical work can provide concrete reinforcement of abstract ideas. The second argument underlines the idea that the students are directed towards understanding the nature of scientific inquiry. On top of this, practical work gives the students experience in problem-solving, provides opportunity for creativity, motivates students and generates interest in developing laboratory skills, such as using equipment safely and accurately and process skills: observing, measuring, classifying and hypothesizing (Dewey; 1995).

Why group work?

I really think that students learn best when they are actively involved in the process. Indeed some studies report that, regardless of the subject matter, students working in small groups tend to learn more of what is taught and retain it longer than when the same content is presented in other instructional formats. Students who work in collaborative groups also appear more satisfied with their classes (Davis; n.d.). For these reasons, I intended to make GW one of the main elements when I was designing the laboratory work.

The Danish students have been accustomed to mature GW skills to some extend from their previous education, but for many international students this approach is quite unique. Since the University of Copenhagen is trying to develop itself as a leading international university and thus trying to attract more international students, it is really important to develop teaching and learning activities that can overcome some barriers to learning induced by the different educational and cultural backgrounds of the students.

My intention was to design activities during the course that could increase student-student interaction and also student-faculty interaction.

Course description

Physical and chemical changes of food quality

"Physical and Chemical Changes of Food Quality" is a course at LIFE at the University of Copenhagen which is offered to students at Bachelor's and Master's degree level. Teaching was conducted over eight weeks on Tuesdays with four hours of lectures and Thursdays with two hours of lectures and six hours of practical exercises.

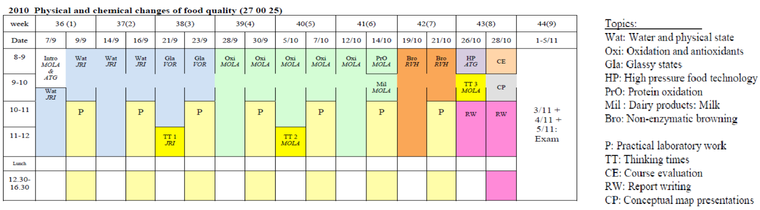


Fig. 12.1. Course structure.

On the course home page, it is stated that the course covers the following topics: thermodynamic stability of food, kinetic description of changes in foods in relation to stability and quality changes, specific physical and chemical processes, control of physical and chemical changes in foods, the use of chemical and physical principles for the description of changes, theoretical and practical experience with several experimental methods for characterization and studying the physical and chemical stability of foods.

Intended learning outcomes of the course

The specific learning objectives of the course are grouped into knowledge skills and competences (taken from the web-page). Students acquire qualifications such as skills and knowledge in the following areas:

- Identify and describe the chemical and physical mechanisms of common physical and chemical deteriorative processes in food.
- Describe commonly applied methods for preventing physical and chemical deteriorative processes in food.

- Apply concepts from chemistry, kinetics and thermodynamics to describe food stability quantitatively.
- Apply selected analytical methods that are relevant for describing physical and chemical food stability.
- Reading and using original scientific literature.
- Present orally and in writing physical and chemical phenomena that are associated with changes of food quality.

Beyond these skills and knowledge, the following academic goal was defined in terms of competences to be assessed and evaluated during the exam: Evaluate and predict the physical and chemical quality of foods based on experimental data and scientific literature.

Course activities

The laboratory practical

A detailed overview of the lab practical was presented to the students on the first day of the course (by me), this presentation was structured as a lecture using a PowerPoint presentation to illustrate graphically the project work to be carried out, the description of the samples to be analyzed and a timetable of the work. I also decided to form heterogeneous groups during this time (based on the results of the first questionnaire, see Appendix A) trying to have groups with at least one international student and one Bachelor's degree student in each group.

During the introductory lecture, I delivered a detailed map of laboratory practicals to each student group. In this map, different laboratory exercises are presented in a form of scientific protocol. At the beginning of the course, I did not give any background on the different techniques to be used during the practical, so that the students had to pay attention during the lectures in order to gain the theoretical knowledge needed to understand the exercises. In this way, the students will start working in the lab from day two without a complete overview or understanding of the experiments. During the practical, the students will receive feedback merely on the experiments.

Other activities during the course

Three more activities have been included in this course:

- Thinking time (to provide formative feedback)
- Design a conceptual map (relate key concepts)
- Presentation peer reviewed (communication skills, ability to criticize)

During the thinking time, the students will have the opportunity to receive active feedback from the teachers regarding theoretical lectures and the practical exercise. To some extent, the thinking time can be considered as a link between the practical and the theoretical lectures. Moreover, during the thinking time, they will be asked to produce a conceptual map, illustrating both the theoretical and practical part of the course. I think that in student learning the designing of a conceptual map is a very important step because it allows the students to see the connections between ideas that they already have, to connect new ideas to knowledge that they already have and to organize ideas in a logical, but not rigid structure that allows future information to be included. Moreover, the process of actually constructing their own conceptual map is a powerful learning tool that in its graphical nature has the force to help and guide the learner to think about the relationships between concepts and ideas. The conceptual map is a key element in this course since it is going to be used by the teacher as one of the tools to assess the ability of the students to relate concepts during their final examination.

The students will have the possibility to present the conceptual map to the other groups and receive feedback from their colleagues. This is also an important element to be included in a course since it stimulates critical thinking and helps students clarify ideas through discussion and debate.

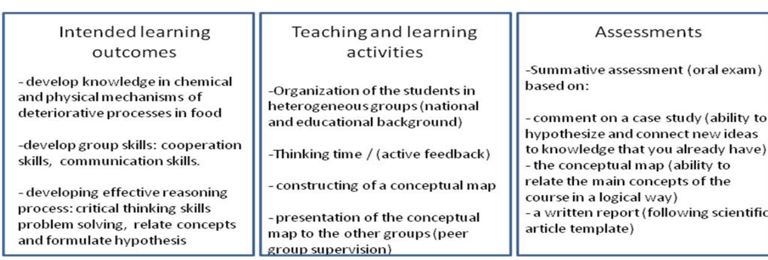


Fig. 12.2. Schematic representation of the alignment of teaching and learning activities.

Evaluation

Questionnaires

In addition to the standard course evaluation sent out to the students through Absalon (virtual learning environment), two additional questionnaires were delivered to the students also using Absalon: a pre-course questionnaire and a mid-course questionnaire. The focus of the first questionnaire was on student background, with regard to nationality, education and experience with GW, and identified students' views on the advantages and disadvantages of GW. The latter was intended to evaluate the students' perception of the GW in this course by using rating scales from “strongly disagree” to “strongly agree” for twelve questions and open answer possibilities for two questions (see Appendix B). The questions were based on other questionnaires used to evaluate GW and collaboration between international students identified from an internet search using the terms “Collaborative learning”, “Co-operative Self-Evaluation” and “Peer Work Group Evaluation” and from identification of specific issues concerning GW based on our own previous experiences.

What did the student say about GW?

The students were generally satisfied with GW and they thought it was a positive experience (see Appendix B for the results of the questionnaire in detail). The majority of the students stated that their group worked together well and that everyone shared responsibility for the work. Despite a good GW environment, students gave different answers on the fact that discussions were dominated by few people, but the disagreements did not delay the work and they still managed to solve the problems that they encountered during group work. One-third of the students disagreed that it was an advantage to have people from different nationalities and that it was an advantage to have people with different educational backgrounds. This was supported by the fact that one-fifth of the students thought that language was a barrier to working well together. Despite these few difficulties, a great majority of students agreed that the GW enhanced their learning and the GW during this course was a successful endeavour for them. Finally, they disagree with the statement that during this course, too much of the teaching was based on group work.

When the students were asked to describe their contribution to the GW, the following key words were recorded:

Organized, efficient, fun, engagement, smiling, organization, responsibility, determination, equal contributions, enjoyable, educatory, participate in discussions, capable of working independently.

The students also listed a few suggestions when asked which changes they would implement in the course. Among these, it was stated that it would be better to change from four to three students per group and that it was a problem to have a group of students following different courses because it made it difficult to find time to meet for writing reports and discussing data.

Final remarks

I found it very interesting to be involved in this project because it also gave me the opportunity to experience how to align intended learning outcomes with teaching activities in connection with other teachers involved in the course. Moreover, I found it very involving to work on student group work (GW) considering the impact of the international and educational background. In the courses in which I am involved, GW is one of the main didactical tools used to facilitate student learning. According to my experience, I consider GW as one of the most stimulating activities for students, but some obstacles are faced by students, especially in an international environment. Among these different cultures, languages and educational backgrounds, barriers could be created between the students and limit their possibilities to succeed. For instance, I realized how important it is to plan each stage of GW carefully from the beginning of the course; like how to organize students in groups and help groups negotiate among themselves, and to provide prompt feedback to the groups. I also think that when making any assignment, it is fundamental to explain the goals of the group and define any key concepts. In addition to a well defined project, every group needs to know the time frame of the various activities and some guidance about the possible contribution of the group members might be necessary, especially in inexperienced groups. It is also important to explain how students will be graded. One of the main messages that I gained from this experience is that the teacher should learn how to deliver the skills to the students which they need to succeed in groups. Many students have never experienced GW and may need practice in such skills as active and tolerant listening, diversity understanding, building more positive heterogeneous relationships, giving and receiving constructive criticism and managing disagreements.

Upon careful analysis, my experience suggests that in order to improve GW from a student perspective, it is important that students are determined to make their self-management skills more effective in a social context. This simple message includes more complex mechanisms, like defining the goal of the project by using a team approach and to know where the GW is leading which should be kept in mind during the process. These mechanisms can be accomplished if the group of students define a clear set of goals to achieve per week over the course, this is a very important step that will ensure that the time-management does not fail and it will remove the destructive feeling of “wasting time” for the group. A few different tools could be suggested for a successful development of the process, like clarifying ideas through discussion and debate. This implies that students learn to criticize ideas and not people. In a more specific context of GW with international students, it is important that cultural differences should be considered as a stimulating factor that could promote the development of oral communication skills and social interaction skills. Under such circumstances, the students involved in international GW activities could develop the ability to view situations from other perspectives. The supervisor also plays a major role in ensuring success in GW and in particular in relation to international GW. The supervisor should provide students with clear learning objectives and a design that assists students to achieve the objectives. In order to achieve this, the supervisor should carefully explain to the students how the groups will operate and how they are going to be graded. When the assignments are given, it is important to define the objectives of the group task. In addition, the groups need to have a mechanism for getting started and a way of knowing when the task is accomplished. Providing a framework already at an early stage during their studies will increase the likelihood of the students paying attention to their own role in taking part and contributing to the group.

Finally, the supervisor needs to give prompt feedback. Knowing what you know and what you do not know focuses learning. Students need prompt feedback on performance to benefit from courses. During lectures and group activities, students need frequent opportunities to perform and receive suggestions for improvements. At various points during their course and at the end, students need chances to reflect on what they have learned and what they still need to learn.

A Pre-course questionnaire

Pre-course questionnaire

Please answer the questions below using your previous experiences from your university education. It should take you about 5-10 minutes. This questionnaire will be used to evaluate the teaching methods in this course.

1. **Name:** ______________________________ **Age:** ________
2. **Nationality:** ____________________

3. **Education (bachelor /master programme + main topic):** ____________________
4. **I have done the main part of my university studies in (Country/Institute)** ____________
5. **I have studied abroad (please circle one): YES NO**
   If yes, please state country/s, institute/s and duration/s____________________
   ____

6. **Prior to this course, how many formal group projects (group work carried out during an academic course ending with completion of a specific task/project) do you estimate that you have participated in during your studies (please circle one)? 0 1-3 4-6 7-10 >10**

7. **I participate in group/team work outside of academic classes, for example, sports or committees (please circle one): YES NO**

8. **In your opinion, what are the top 3 advantages of group work?**
   ____
   ____
   ____

9. **In your opinion, what are the top 3 disadvantages of group work?**
   ____
   ____
   ____

10. **Personally I would prefer to work independently rather than in a group (please circle one):**
    YES NO

Thank you for your participation.

During the course you will receive a follow-up questionnaire regarding your specific experiences during this course.

B Mid-course questionnaire

	Course	Physical and Chemical Changes of Food Quality B1-1E10-UE (EKursusLife49500211-bb211-kk2700)
1	In general, my group worked well together:	Average: 3.96
		Standard deviation: 1.10
	1	4,2%
	2	8,3%
	3	12,5%
	4	37,5%
	5	37,5%
2	The other members of the group would agree with my evaluation of the above statement:	Average: 4.08
		Standard deviation: 0.81
	1	4,2%
	2	0%
	3	4,2%
	4	66,7%
	5	25%
3	In my group, everyone shared responsibility for the work:	Average: 3.91
		Standard deviation: 1.18
	1	8,3%
	2	4,2%
	3	8,3%

	4	41,7%
	5	33,3%
	Not answered	4,2%
4	In my group, discussions were dominated by a few people:	Average: 2.88
		Standard deviation: 1.30
	1	20,8%
	2	16,7%
	3	29,2%
	4	20,8%
	5	12,5%
5	In my group, the work was substantially delayed because of	Average: 1.75
	disagreements:	Standard deviation: 1.23
	1	62,5%
	2	20,8%
	3	4,2%
	4	4,2%
	5	8,3%
6	In my group, we solved the problems that we encountered	Average: 3.87
	during the group work:	Standard deviation: 1.03
	1	0%
	2	12,5%
	3	20,8%
	4	29,2%
	5	33,3%
	Not answered	4,2%
7	In my group, it was an advantage to have people with different	Average: 2.65
	nationalities:	Standard deviation: 1.27
	1	25%
	2	12,5%
	3	41,7%
	4	4,2%
	5	12,5%
	Not answered	4,2%
8	In my group, it was an advantage to have people with different	Average: 2.88
	educational background:	Standard deviation: 1.05
	1	12,5%
	2	16,7%
	3	50%
	4	12,5%
	5	8,3%
9	In my group, language was a barrier to working well together:	Average: 2.74
		Standard deviation: 1.36
	1	20,8%
	2	29,2%
	3	12,5%
	4	20,8%
	5	12,5%
	Not answered	4,2%
10	During this course, the group work enhanced my learning:	Average: 3.46
		Standard deviation: 1.08
	1	8,3%
	2	8,3%
	3	25%
	4	45,8%
	5	12,5%
11	During this course, too much of the teaching was based on group	Average: 2.25
	work:	Standard deviation: 1.13
	1	33,3%
	2	25%
	3	29,2%
	4	8,3%
	5	4,2%
12	All in all, group work during this course was a successful	Average: 3.67
	endeavour for me:	Standard deviation: 1.07
	1	8,3%
	2	0%
	3	29,2%

Part III

Diversity in the students' background

13

Peer feedback on a test exam and self-reflections on academic English – tools for reducing failure rate in the written exam in Nutrition Physiology, after change of language into English

Alicja Budek Mark and Lesli Hingstrup Larsen

Department of Human Nutrition, LIFE, University of Copenhagen

Introduction

Nutrition Physiology (NP) is a mandatory course for students taking a Master's degree in Human Nutrition, in Clinical Nutrition or in Gastronomy and Health. The course is in the first block in the first year of the Master's programme. The course is theoretical, with lectures and theoretical exercises, and the evaluation is a final four-hour written examination with all aids allowed (except computer/internet). The course runs in parallel with Experimental Nutrition Physiology (Nutrition) or Hygiene and Sanitation (Gastronomy and Health).

The Master's programmes admit graduates with a university BSc degree (for example, Sport Sciences, Biology, Food Science, Health and Production), referred to as UB, or a professional BSc degree (for example, Nutrition and Health, nurses, physiotherapists, lab technicians), referred to as PB, with additional courses in biochemistry, physiology, nutrition and statistics equivalent to what would have been obtained with a BSc degree in Food Science with the Food, Health and Nutrition subject-specific course package.

In 2009, the language of instruction and examination for NP changed from Danish to English, and 82 students took the four-hour written exam. In contrast to previous years, the percentage of students who passed the exam was only 75% and the grade point average was 3.9.

After evaluating the 2009 course, the low pass rate was mostly ascribed to problems with written academic English in the context of the course topics and additionally some of the problems could be due to students' difficulty in understanding academic English. Difficulty with the English language could increase the students' anxiety before the exam, and increase the time spent on understanding the exam questions, considering the answer to the problem by rephrasing from mother tongue to English, correcting spelling and grammar, and writing the answers in English.

Based on the conclusion that the academic English level seemed to be the obvious reason for the observed fall in the pass percentage, it was decided to offer the student a short English course from at the university's Centre for Internationalisation and Parallel Language Use (CIP) during the introduction week to make them aware of their own English abilities and give them tools to practise in the areas where their current level was not adequate.

For the NP course, we would ideally align the teaching with the exam and include a written assignment with feedback to the students from the lecturer in every lecture. This would give the students the opportunity to structure their knowledge, read and understand the questions in English, formulate and write an answer in English, and receive the necessary feedback to get a view of the requirements for fulfilling the learning objectives and passing the exam. In reality, however, with a course with multiple lecturers this is not feasible. Instead, we decided to ask all the lecturers to include theoretical exercises in their lectures, to encourage the students to use English as their main language when doing the exercises, and to discuss the assignments with the students.

Additional analyses of the 2009 exam results showed that the PB students had nearly double the failure rate (34%) of the UB students (18%) (Fig. 13.1). These results made us wonder if the UB students might have evolved strategies to deal with the exam situation (because they had previously been in similar exam situations) and have better study techniques (university-based) than PB students.

The evidence that not only English competence but also the BSc educational background influenced the exam results suggested that we should use additional measures to increase the constructive alignment between lessons and assessment beyond just requesting multiple lectures (see above) to add additional exercises and encourage the use of written English (in reality it is difficult to ask lecturers to make sure that everything on their slides are in English). We decided to introduce a mock exam and peer feedback session (PFS) mid-way through the course. The peer feedback (PF) would give the students an opportunity to gain experience with writing a full exam

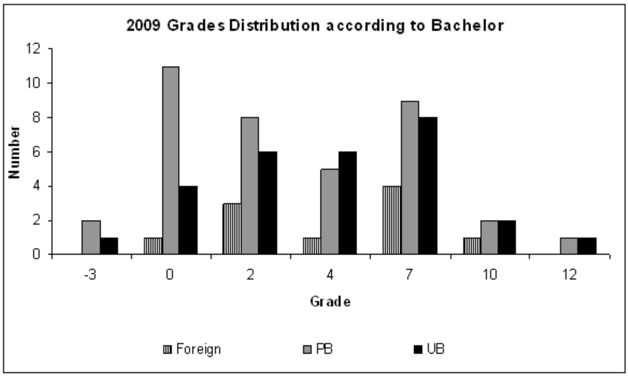


Fig. 13.1. 2009 NP exam results for students divided according to BSc educational background. Foreign, students from abroad; PB, profession Bachelor's degree; UB, university Bachelor's degree.

in English within a four-hour time limit, evaluate their own performance, give and receive feedback from one of their peers, have a group discussion of the problems and their solution during the exam, and exchange exam strategies. Our goal was to reduce the likelihood that, in addition to inadequate written English skills, lack of experience with the exam situation at the university would detract from the students' abilities, independently of BSc background, to adequately show fulfilment of the intended learning outcomes for the course at the exam.

The aim of this project was to evaluate if the students had engaged in self-reflection on their English ability (with or without participation in the CIP course), to evaluate if the students found the peer feedback session useful, and to evaluate whether these tools could reduce the failure rate in the written four-hour NP exam compared with the previous exam (2009).

Methods

The CIP test

The CIP test was arranged by the CIP at the University of Copenhagen as an aid for the students in the first year of the Master's programme to diagnose their English skills and their possible need for improvement of

English competences. The students were free to take the CIP test before the beginning of block 1 of the first year of the Master's programme. In this report, we have evaluated the answers of the students on the NP course who took the CIP test with regard to any subjective effect on the students' approach to their English skills during the NP course.

The peer-feedback session (PFS)

As part of the NP course this year, we have introduced a mock four-hour exam set as an assignment uploaded on Absalon for the students to work on individually and a PF process where the students could read and comment on each other's answers in the PF groups. The PF groups have been formed to allow as much variation in academic background as possible in order to share competences. The groups were also used for theoretical exercises before the PFS to give the students the opportunity to get to know their group members. The assignment enabled students to experience the exam situation, and reflect on how they could best convey all their academic knowledge in a precise manner within a limited period of time. The students could attempt to complete the work in the restricted time with the exam set and they had the opportunity to see and correct another student's work. As the last part of the PFS, the students were to have a meta-discussion of the exam situation based on their experiences with the mock exam. The results were one page of student-to-student advice on managing the exam situation without compromising their academic level. The students were asked to evaluate the PFS afterwards.

The exam results from 2009 and 2010

We compared the results of the exam from 2009 and 2010 and used them as an element to evaluate the effects of the new initiatives at the start of and during the NP course.

Statistics

SAS program (version 9.2; SAS Institute Inc., Cary, NC, USA) was used for data analysis and the bivariate associations between the selected variables were tested by Pearson's correlation coefficients.

Results

From all the students registered for the exam in NP in 2010 (n=68), 31 (46%) returned the questionnaire, among whom two individuals did not participate in the PFS and 29 (43%) participated in the PFS. At the lecture after the PFS, the students were asked to fill out questions one to four to evaluate the value of the CIP, however, none of the students returned the questionnaire. Of the 29 students who participated in the PF and returned the questionnaire, one student did not state academic background and thus this response was omitted from the analysis. Of the remaining 28 students, 50% had a PB and 50% UB background.

Evaluation of CIP

The CIP evaluation was based on the 29 students who participated in the PFS: 57% of PB and 53% of UB students took the CIP test and course, respectively. Only 14% of all students who took the CIP test decided to practise their academic English skills during the course (11% of PB and 4% of UB students, respectively). There was no significant correlation between students' background and the consideration of the language before taking the course, or between the consideration of the language before taking the course and the difficulty in keeping the academic level of the written exam test.

The most common reasons for not practising English skills were:
a) "But not as much as I would like to ... lack of the time"
b) "I am using English dictionaries to increase my vocabulary"

The most common reasons for not practising the English skills were:
a) "I was placed in the top category, so I did not find it necessary"
b) "I don't consider my English as an obstacle"
c) "I don't have time"
d) "no, but I will consider it"

Half of the PB students evaluated their English skills while only 21% of UB students did so before taking the NP course (Fig. 13.2). Of the UB students, 71% did not evaluate their English skills before taking the NP course.

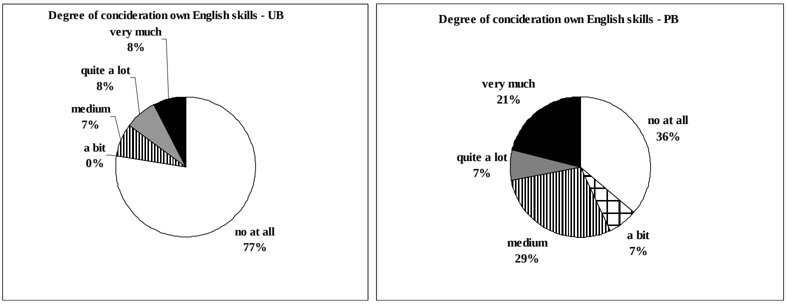


Fig. 13.2. Degree of evaluation of own English skills before applying for the NP course by profession Bachelor students (PB) and by university Bachelor students (UB).

Evaluation of PFS

Of all students who registered for the exam on the NP course, 41% (n=28) took part in the peer feedback session. The students reported their expectations that the PFS would give them a better overview, help them to understand what the exam will look like and what the expectations are, would be a good opportunity to practise for the exam and to get feedback on the academic and structural part of the exam as well as to get advice on exam strategies.

All but one student wrote the answers in English. Regarding the difficulty of keeping a high academic level in English while answering the exam questions, 57% and 36% of the PB and UB students, respectively, answered that it was very or quite difficult. The majority of PB students thought that it was quite difficult, while the majority of UB students thought that it was only a bit difficult. There was no significant correlation between students' background and the difficulty of keeping the academic level of the written mock exam.

For 64% of PB and 78% of UB students, it took longer than expected to write down the answers in English. In many cases, for the PB students the English was an obstacle. It took them longer time to read the questions, understand them and to formulate the answer in English, especially, the English was not academic enough. For one student the calculations took a long time and a few students did not have an overview of the curriculum. In contrast, for most UB students, it was difficult to figure out the depth of the questions and how specific one should be in answering them. Many of the students had not read the entire curriculum yet and some made a lot of breaks while answering the questions. For one student, there were too many questions and it took too long time to look it up and explain properly.

After the PFS, 15% of PB and 47% of UB students did not consider at all changing their previous opinions about their own English skills based on CIP. 62% of PB and 27% of UB students had changed the previous evaluation of their own English skills only a bit. The majority of both kinds of students thought that the PFS would benefit them during the exam; 84% and 75% of PB and UB students, respectively. However, 6% and 13% of the UB students thought that the session did not benefit them at all or only a bit, compared with 0% and 8% of PB students, respectively (Fig. 13.3).

Regarding receiving and giving peer feedback, 55% of the PB and UB students answered that the degree of benefit was "medium".

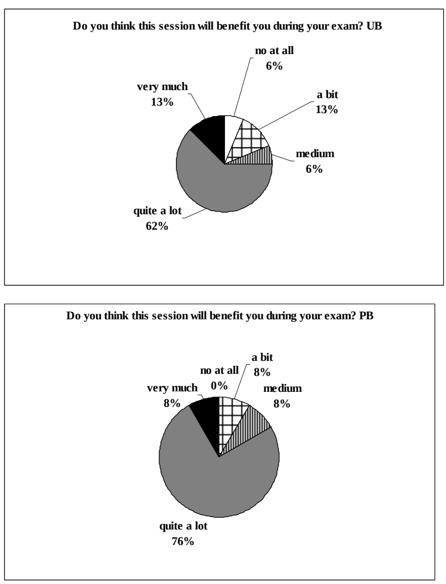


Fig. 13.3. The degree of benefit of the peer-feedback session for the profession Bachelor students (PB) and university Bachelor students (UB).

Evaluation of the exam from 2009 and 2010

In 2009, 25.6% of the students failed the exam and the grade-point average was 3.9. In 2010, just 4.5% of the students failed the exam and the grade-point average was 5.6.

Discussion

Overall, 46% of the students filled in the questionnaire and 43% took part in the PFS session. The students who took part in the PFS were equally divided between PB and UB educational backgrounds. Overall, the students found that they benefitted from the mock exam and the PFS. Only a minority of the students had taken the CIP test and course, and only 14% of the students had worked on their academic English after the CIP course and a majority of these were PB students. The PB students had also reviewed their English skills before enrolling in the Master's programme much more frequently than UB students.

The PFS process was changed on the last day, as many students had not exchanged their work, as indicated by most students stating that they had received only medium feedback from their peers. Instead, solutions to the assignment were handed out to the students and the groups were aided with work sheets to get to the meta-discussion. All groups were very good at discussing, they handed in the results of their discussions, and the summing-up of the discussion indicated that the exam situation had been discussed. The student-to-student advice notes on exam strategies were uploaded on Absalon for all students to see. As stated earlier, most students evaluated that the PFSs session were beneficial for them. However, in the general course evaluation, some students suggested improvements to the organization of the PFS. Some of the students (i)would like to be informed at an earlier time point about the PFS; (ii) did not appreciate the predefined groups because six members were too many; people with different competencies slowed down the group progress and they preferred to work alone or in pairs; (iii) did not feel comfortable sharing their work with fellow students or felt they did not have the skills to evaluate other students' work; (iv) felt that this way of teaching was not university level but more kindergarten level.

The first trial of the PFS and the evaluations from the students suggested that we should modify the PFS by an earlier introduction with more details to relieve any anxiety and for the students to understand what the intended benefits could be from the session. The PFS should also have been much more structured to keep the group discussions focused and should be divided into smaller sessions, working with one work sheet at a time and summing up on the blackboard after each session. We would like to keep the predefined groups to mix the students so they can benefit from each other during the learning process. From previous years, we know that the students do not mix in block 1 when they are allowed to form their own groups, however, as the parallel courses are also using group work, it might be possible to use the same groups or maybe have smaller groups.

The CIP test was introduced as part of the introduction week to give the students an opportunity to review their level of academic English and work to improve the level if needed. This project also asked the students about their self-reflection on their English abilities before and after taking the CIP test. However, the results are limited as only a minority of the students who participated in the PFS participated in the CIP test during the introduction week. The result of the CIP test had a relatively low impact on students' evaluation of their English skills, especially among the UB students. Slightly more PB than UB students reviewed their English skills before taking the course, but there were no significant correlations between these two factors.

The exam results for 2010 had a very low failure rate (5%) and two of the students who failed were students from 2009 retaking the exam. The results from 2010 indicate that the additional CIP introduction course, although only about half of the students participated, increased the students' awareness of their level of academic English. However, many students stated in the evaluation that they lack time to practise and, in the general evaluation of the course, some students said they would like to have more exam assignments to practise the curriculum but also the use of academic English. Most students also appreciate all the exercises and would like to have more exercises during the lectures (and some would like separate lectures and exercises). We will include more exercises for the students next year, and we will discuss with the CIP course leaders if it is possible to integrate the tools for practising academic English with the NP exercises.

This project has some limitations that impede the interpretations of the results: the exam sets were not identical, the students represent two different student bodies and only about half of the students answered the questionnaire. As two different student bodies are compared with regard to exam results, other factors could have played a part in determining the difference in pass percentages for 2009 and 2010. One main factor is the admission requirements: in 2010, several PB students were declined admission as they had not fulfilled the requirements in physiology, biochemistry and statistics while most applicants were admitted in 2009. As a consequence, the exam results might also reflect a difference in the student body from 2009 to 2010. As only 46% of the students who signed up for the exam answered the questionnaire, we are left guessing what the other half of the students think. It is possible that the students who participated in the peer feedback are the students who are already very active and have a very high study capacity, as one student wrote in reply to "Why you are participating in the peer feedback session": "I'm always there when something is planned/goes on". However, most students wrote that they thought that they needed to discuss or get to know exam strategies, so the PFS could have activated the students who might have contemplated the exam situation at great length before.

In 2011, we will also give the students the opportunity to take the CIP course in the introduction week as the results from 2010 have shown that this will force the students, participating or not, to reflect upon the issue of English as a learning language. As most of the students who participated in the exam test and PFS found it beneficial, we will offer a similar session in 2011. At present, we are considering offering some additional seminars for the students, working with student services, to introduce students coming from outside the university to the university environment.

14

Teaching students with different backgrounds and different chosen education lines

Mingshi Yang

Department of Pharmaceutics and Analytical Chemistry, FARMA, University of Copenhagen

Background

Pharmaceutics and Drug Development (PDD) is a cource in the Master's in Pharmaceutical Sciences. This course has been held once, in autumn 2010, and at the time of writing it is being organized for the second time. The students who were enrolled in this programme held their Bachelor's degree in various disciplines such as biology, chemistry and medicine. At the start of their Master's programme, they chose one of three education lines: Drug Discovery, Drug Development and Social Pharmacy. PDD is one of three compulsory courses in block I and II.

The feedback from the students' evaluation in 2010 was very mixed. For example, only two-thirds of the students found the course useful for their educational objectives, but on the other hand most of them found the laboratory exercises relevant. Some of the students found the content of the course not to be MSc level and too basic. This might be because the teaching was mainly based on a text book for normal pharmacy undergraduate students. However, the course was meant as an introduction to formulations and manufacturing and therefore it covered broad topics. This means that none of the topics can be covered in detail. Hence, one of the challenges in the course is that the students have various backgrounds and have very different expectations of this course, and it is difficult to tailor such a course to suit every student.

Plan and execution of project

This project is intended to identify students' expectations and evaluate TLAs in order to design a more relevant course for students who have chosen different education lines. A questionnaire was conducted to identify the students' expectation before starting the course. A mixed teaching format was planned: lectures, laboratory exercises and literature reports. The lectures were divided into two parts. One part was given before starting the lab exercise. The other part was planned after the lab exercise.

In the first part, the lectures were focused on basic theoretical knowledge of pharmaceutics, using the text book for normal pharmacy undergraduate students. These lectures were intended to help the students to understand the lab content and facilitate completing the lab exercises. In turn, the lab exercises were intended to help students digest the theoretical knowledge learned in the lectures.

In the second part of the lectures, two senior scientists from the pharmaceutical industry were invited to hold two sessions, and their talks would be focused on the relevance of this course to the pharmaceutical industry and the society. Meanwhile, two lectures were planned to introduce students to advanced pharmaceutics and drug delivery systems.

A mid-way evaluation of the course was conducted after the first part of the lecture and the lab exercises. The students were asked to fill out a short questionnaire and give comments on the course. An interview with lab teachers was also conducted to have their input on this course. The final evaluation of the course was to be carried out at the end of January 2011. Due to the time limit (deadline of project is 6 January 2011), this report was drafted based on the expectation survey, the mid-way evaluation and the interview with lab teachers. The project will continue when the final evaluation of the course is received.

Summary of expectation survey, mid-way evaluation and interview with lab teachers

Students' expectation of this course (26 students replied)

As shown in figure 14.1, the students in this course are from ten different disciplines. Ten of them have pharmacy Bachelor's degree. The rest of them have Bachelor's degrees in biology, chemistry, biotechnology and medicine etc. Among them ten students chose Line II: Drug Development, five chose Line I: Drug Discovery, and six chose Line III: Society and Medicine. Five students were enrolled as Erasmus students, as shown in figure 14.2, who were on pharmaceutics courses back in their own faculties.

Bachelor degree	No. of student	Bachelor degree	No. of student
Biochemistry	2	Medicine	1
Biology	3	Molecular Biology	1
Biotechnology	3	Molecular Biomedicine	1
Chemistry	3	Nanoscience	1
Chemical Engineering	1	Pharmacy	10

Fig. 14.1. Bachelor degrees held by the students.

Lines	No. of students
Line I: Drug discovery	5
Line II: Drug development	10
Line III: Medicine and society	6
Others	5

Fig. 14.2. Education lines that the students chose.

According to the survey, the students' expectation of this course could be divided into four aspects: basic pharmaceutics, hands-on experience (laboratory exercise), advanced pharmaceutics and GMP rules. Out of 26 students, 21 expected to learn basic knowledge and an overview of pharmaceutics and drug development. This fits quite well with the objective of this course, which is intended to give an overview of and introduction to pharmaceutics and drug development to the students. Interestingly, 12 out of the 26 students pointed out that they looked forward to lab exercises and gaining some hands-on experience in drug manufacturing and formulation development.

- A Line II student: I'd like to do more laboratory exercises to learn how to manufacture products and to see how to use GMP rules. This course can help me understand manufacturing process of different dosage forms.
- A Line I student: I expect to get an overview of the drug development phase and a thorough insight into the formulation and manufacturing processes of drug development. I expect to learn the key theoretical concepts and to get some hands-on experience.

Five out of 26 students expressed their expectation of gaining deeper insight in advanced pharmaceutics and drug delivery systems. Another three students would like to learn more about GMP rules from this course, as one student wrote: "I would like to have an extended and more professional pharmaceutical technology knowledge which covers GMP rules and more". Apparently, their expectation somewhat exceeds the scope of this course and they wanted to gain more profound knowledge on this subject. However, it is hard to say that the different expectations are due to the different education lines they have chosen. Instead, the different expectation seemed to be correlated to students' backgrounds, e.g. pharmacy students expected a higher level of this subject.

Meanwhile, in the questionnaire, students were also asked to comment on whether this course is relevant to their education lines. Most of the students (19 out of 26 students) are positive towards the relevance of the course to their education line, although among them three are Erasmus students.

- A Line III student: I think it is good to get an understanding of the drug-development process, even though this will not be my primary interest field when I get a job.

Four students were not sure about whether this course was really relevant to their chosen lines: "Not sure at this point. Maybe will know at the end of the course.". And three students did not think this course is relevant to their education line. But these students stated that this course is relevant to the Master's programme or it will help them to understand better the line they have chosen: "It is relevant to the master program, but not that relevant to my line, since I chose Line I", "It is basic knowledge to better understand my own field – yes. However, practically not (relevant to my line)", "I think that is not really relevant as in the third line we focus more on the social part of pharmacy but definitely is a prerequisite, because we should know how the drugs are formulated in order to be the final medicines". This indicates that the students were a bit unclear about the role of this course in the

Master's programme. They believe this course is more relevant to Line II than other lines. They took this course because it is a compulsory course. More guidance to the students on how this course aligns with other courses in the education lines should be given to the students, which may need to be included in learning objectives of this course.

Mid-way evaluation of the course (21 students replied)

The course consists of four elements: lecture, laboratory exercise, literature report and examination. This mid-way evaluation was conducted after the students had attended the first part of the lectures and all the laboratory exercises. The literature report project was also initiated, but will continue until examination at the end of January 2011.

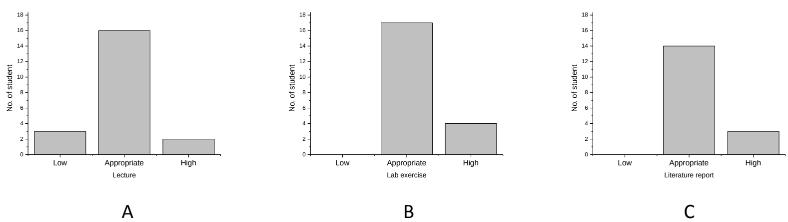


Fig. 14.3. Feedback on the level of content. A: lecture; B: lab exercise; C: literature report (four students did not reply on literature report).

Regarding the content of each teaching element, three students commented that the level of lecture content was low and two students commented that it was high, as shown in figure 14.3A. The rest of the students considered the level of lecture content appropriate. For the lab exercise and literature report, none of the students felt the level was low. But a few found the level was high.

About 80% of the students (16/21) found the workload in lab exercises too high, and they could not find time to work on literature reports. This is most likely because of the block structure. These students have to attend two or three times lab sessions per week, while normal undergraduate pharmacy students attend only once per week. The workload on the lab exercises was actually designed to suit the one-week workload for normal undergraduate pharmacy students. Hence, the workload in the current format for these students is about two to three times higher than for normal undergraduate students. Meanwhile, a more thorough introduction for the students on how the lab exercise is organized, how the students should conduct the exercises and how to prepare lab reports seemed desirable. Students praised the content of the lab exercises, but they were not used to the structure of lab teaching. An introduction lecture will facilitate students' lab work and motivate them.

A few students commented on examination of the literature report. The literature report is intended to let students have a chance to get a feeling of advanced drug-delivery systems, since the lecture and lab exercises are mainly focused on basic pharmaceutics. Some students commented that the 2010 course was not at Master's level due to its main focus on basic pharmaceutics. In the literature project, students were divided into some groups with four to five members in one group. They were required to write 20-25 pages per group on a specific topic assigned by a supervisor through literature searching, summarizing and compiling. Very often, such topics are about advanced pharmaceutics since the supervisors usually assign a topic related to their own research interest. But the topics are also very specific, and the scope is rather narrow. Furthermore, the format of examination is oral presentation and questioning. Hence an examination on the literature report may not reflect students' true understanding of this subject (pharmaceutics and drug development).

Interview with lab teachers

Three lab teachers were interviewed after the mid-way evaluation of the course with students. Most of the feedback from them was consistent with the comments from the students. All of them agreed that an introductory lecture on lab exercises was needed. In that lecture, the teachers can emphasize the goal of the lab course, instruct preparation of lab reports, tell what the teachers expect from them and what the students could expect from the teachers as well. They also pointed out that the workload seemed to be high for the students with the current content of lab exercises and block structure system. Again, since the students have put more time into lab exercises and lab reports, it may make more sense to assess the students based on lab reports rather than literature reports. It may also motivate the students on the lab courses more.

Discussion

It is inevitable to have students in a class who have different backgrounds and with different aims to pursue. The motivation of this project is that an early identification of the expectations of students may help a course leader to coordinate the course (between teachers and students) and keep motivating students during the course by adjusting some of the teaching elements accordingly. It is not possible to satisfy every student's expectation. However, by knowing students' expectations at an early stage a course leader may be able to prevent frustration caused by mismatch of expectations between teachers and students. A questionnaire survey was used in this project. The advantages of questionnaire survey include its possibility of producing higher response rate, saving time and an anonymous approach so students could feel free to express any concerns. The disadvantage of such a survey is that it is not possible to get deeper understanding of issues or thoughts. Nevertheless, it is still a good approach to grasp information in a broad manner.

The questionnaire survey showed that the students' expectations aligned well with the objectives of this course. Most of them expected to have an introduction to pharmaceutics and drug development. Some students would like to have more profound knowledge on the subject. Most of these students had degrees in pharmacy and had already completed pharmaceutics courses during their undergraduate study. Hence, their expectation of this course was higher than other students who held Bachelor degrees in disciplines other than pharmacy. However, this course was planned to be an introductory course in the Master's programme. The teaching materials employed in the course are mainly used for normal pharmacy Bachelor students. To avoid some students becoming bored with basic knowledge, lecturers on the course were encouraged to spice the lectures with their own research. Meanwhile, lecturers from industry were also invited in the second part of lectures to address the development of drug products in pharmaceutical industry.

Students found lab exercises very exciting and lab teaching motivated them. Some students even looked forward to lab exercises prior to the course. It is always one of the best ways for learning to combine theoretical knowledge with hands-on practice in teaching. However, the lab exercises in this course consist of both formulation and manufacturing sections, which were designed by two teaching groups, consequently students were quite confused about the structure. Meanwhile, the workload on lab reports was too high, which may risk demotivating students. This may be the reasons why some students commented that the level of the lab exercise was a bit high. Some students also evaluated the level of the literature report to be high. One reason may be the fact that the topics assigned by supervisors were too specific and exceeded the scope of the teaching materials used in the lectures. Both students and teachers also pointed out that a final examination based mainly on the literature report might not adequately reflect students' learning (Gibbs & Simpson; 2003).

The above analysis of the survey suggests that there is room for improvement of the teaching and learning activities (TLAs) to implement constructive alignment of the current course (Biggs & Tang; 2007). Lectures should focus on introducing students to theoretical knowledge in the subject. Lecturers can be encouraged to apply more active teaching in the lecture to get the students involved in class discussion. In this way, teachers can sense whether the students with different undergraduate backgrounds understand the topics correctly. The content of the lectures can still be at normal undergraduate pharmacy level, since interested students who would like to gain profound knowledge in advanced pharmaceutics have chances to attend elective courses on Advanced Drug Delivery and Advanced Drug Manufacturing in block 4 or second-year study.

Lab exercise is certainly a valuable teaching element in this course. Students have the chance to work in a group, to solve problems and address questions together (Tamir; 1989). Meanwhile the students have more chances to interact closely with teachers. The structure of lab exercises may need an effort to be aligned (i.e. formulation and manufacturing) and a more thorough introduction to lab exercises is required prior to starting the course. For the high workload, the ideal solution is to spread the lab course over a longer period, e.g. one exercise per week. However, it may be quite challenging to do so due to the block structure. Another solution is to decrease the content of lab exercises and lab reports, which should be carefully adjusted by evaluating the alignment between ILOs and this teaching activity.

Serious consideration should be given to the literature report and assessment. The literature project could be a good student-centred activity where students can work in groups to deal with all the important aspects of formulation, production and biopharmaceutical characteristics based on one or more specific drugs. An assessment on such project may align well with ILOs and reflect the students' learning (Gibbs & Simpson; 2003). It requires more competent supervisors who can define appropriate projects to students and fairly assess the students during examination, however, due to limited resources, most of the supervisors in this course are PhD students and postdocs. An improvement may be achieved by shortening the literature reports and assess students' learning on both lab reports and literature reports. Thus students may also feel appreciated for their hard work on lab exercises. A lab teacher also suggested introducing a written examination in the course, but its applicability need to be further debated. Another improvement that should be considered is to apply more formative feedback in correcting the lab reports than summative feedback. Students usually learn more from formative feedback than summative feedback which has been shown in didactics studies (Yorke; 2003).

Conclusion

An early identification of students' expectation and mid-way evaluation could provide a course leader with valuable insight in students' motivation and course structure. It is especially helpful for coordinating and teaching a course where the students have different background and have chosen different education lines. The questionnaire survey showed that the students' expectation of this course seemed to differ, mainly because of their different backgrounds rather than the education lines chosen. Most of the students recognized the relevance of this course to their own education lines. The mid-way feedback from the students indicated that they appreciated TLAs in this course, which included lectures, lab exercises and literature report. However, there is room for improvement on the lab course structure and the literature report project. Further improvement should also be focused on the structure of the course by optimizing the alignment of ILOs, TLAs and assessment.

The author thanks Jørn Møller Sonnergaard, Marja Savolainen, Jukka Rantanen and Birger Brodin Larsen for their valuable discussion and comments during the project.

A Questionnaire survey on students' expectation

Pharmaceutics and Drug Development:

1. You got your bachelor degree in:

Biochemistry		Medicinal Chemistry	
Biology		Molecular Biology	
Biotechnology		Molecular Biomedicine	
Chemistry		Molecular Medicine	
Chemical Engineering		Nanoscience	
Engineering		Pharmacy	
Medicine		Science	
Others:			

2. Your education line:

Line I: Drug discovery	
Line II: Drug development	
Line III: Medicine and society	
Others	

3. What is your expectation of this course?

4. Do you think this course is relevant to your education line? Why or why not?

5. Regarding groups, you wish to form

by yourself	
by course leader	
Do not care.	

B Survey on mid-way evaluation of the course

Middle way evaluation of the course (5-10 min):

The course has passed one month. Please help us improve the quality of teaching.

1. **You got bachelor degree in:**

Analytical chemistry		Medicinal biology	
Biochemistry		Medicine	
Bioengineering		Molecular Biology	
Biology		Molecular Biomedicine	
Biotechnology		Molecular Medicine	
Chemistry		Nanoscience	
Chemical Engineering		Organic chemistry	
Medicinal Chemistry		Pharmacy	

2. **You education line is:**

Drug discovery	
Drug development	
Medicine and society	
Others	

3. **How was the level of the content?**

Level / Content	**Low**	**Appropriate**	**High**
Lectures			
Lab exercises			
Literature report project			

4. **How was the course structure i.e. lecture, lab exercise and literature report? Should any of them be reduced or increased?**

5. **What do you miss from this course? Or would you like to have other elements in the course? (considering the education line you chose)**

15

Towards a balanced curriculum and fair assessment of students from different disciplines in an interdisciplinary science course.

Sine Lo Svenningsen

Institute of Biology, SCIENCE, University of Copenhagen

Objectives

The project aims to improve the course Biological Dynamics, which will be offered for the second time in block 4, 2011, based on the students' evaluations from 2010 and my experiences from giving the course in 2010.

I will focus on the main challenges we encountered in the course. One objective is to plan the curriculum and the teaching activities so that students, despite different educational backgrounds, feel both confident and challenged, and experience a positive learning climate. Another is to develop teaching activities which are aligned with the overall aim of the course, namely promoting interdisciplinarity and equipping students with a common language with which to discuss topics that cover multiple disciplines. Finally, I will discuss the challenge of assessing the course participants fairly, so that students from all backgrounds have an equal opportunity to do well in the course provided they put in the effort.

Background

The field of molecular biology is advancing from the qualitative description of isolated molecular mechanisms to a quantitative understanding also of their interactions and regulations at the "systems-level". Thus, the common notion of biology being the ideal discipline for the "scientifically inclined but mathematically challenged" students needs revision, and this development has produced a challenge for the educational system. The advantage of quantitative approaches in biology has always been apparent, but the application of mathematical skills to create simulations or manage large data sets means that the need for basic mathematical literacy in biology has never been greater (Wingreen & Botstein; 2006; Gross; 2004). Biological Dynamics was created to address the challenge at the Master's level, where many students have already solidly identified themselves as biologists, chemists, physicists, and so on. The aims of the course are to educate students from different disciplines in the interdisciplinary skill set between biology, physics, and mathematics, which is necessary for a modern integrated understanding of biological systems, and also to teach the students how to communicate with peers educated in disciplines other than their own.

Biological Dynamics is co-organized by myself and Namiko Mitarai, an associate professor in the physics department. The course is inspired by an interdisciplinary course in quantitative biology that I attended at Princeton University, USA, in 2006 (Wingreen & Botstein; 2006).

The course is open to students from most of the disciplines at the Faculty of Science. In the past year we had a total of 51 students from eight different educational backgrounds (biology, biochemistry, bioinformatics, molecular biomedicine, biophysics, physics, maths, and computer science). We do not make specific course prerequisites but ask that students who sign up have an interest in the quantitative analysis of biological phenomena.

Balancing the curriculum

We chose to centre the course around a curriculum of eight scientific articles, one per week. The nature and quality of the articles are of paramount importance for the success of the course for several reasons. First, they must serve as vehicles for teaching both biology and quantitative analysis. Second, they constitute proof for the students that important scientific insights can be gained from an interdisciplinary approach, and must be sufficiently sophisticated to withstand detailed study and to inspire the students. These were our criteria for selecting the articles.

Namiko and I developed introductory lectures in physics and biology, respectively. Initially, our intentions with the lectures were twofold: First, to provide the disciplinary background knowledge required for understanding the articles and second, to put the article into context by deepening and widening the students' insight into the topic beyond the specific hypotheses treated in the article. During a normal week, students would attend the introductory lectures on Monday, read the article at home, and participate in a class discussion about the article on Wednesday. Importantly, the curriculum consisted of the lecture notes as well as the articles.

I found it challenging to define a level of difficulty in my lectures such that every student would benefit from attending. To obtain feedback from the students on the perceived level of difficulty in the material of the lectures, I often asked for a show of hands during the lecture from anyone who had "learned something new" after the first 5-10 minutes of introduction to the topic. I found this to be a reasonable measure of the students' prior knowledge of the topic. We also made a midway evaluation after the first four weeks of the course. To be able to take the students' background into account, we asked them to indicate their educational background on the evaluation.

What is your educational background?	Students' answer	Total students enrolled
Biology-oriented	19	27
Physics-oriented	4	11
Equally Biology and Physics-oriented	10	11
Other (math/computer science)	2	2
Prefer not to answer	0	
Total	35	51

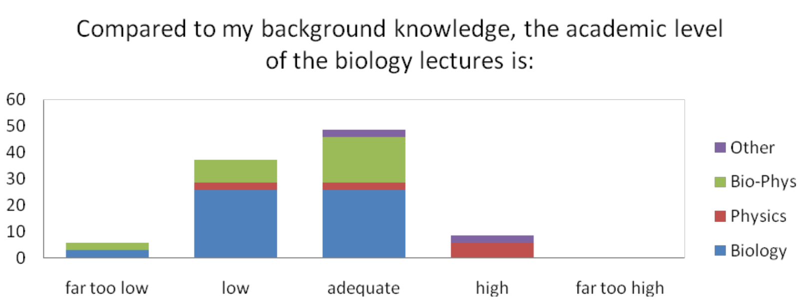


Fig. 15.1. Midway evaluation. The percentage of students giving the indicated answer is shown on the Y-axis. Colours indicate the educational background of the students. A total of 35 students answered this question.

In total, 45% of the students indicated that the academic level of my lectures was either “far too low” or “low”. Noticeably, all but one of these students had a background in either biology or biophysics, and the 9% of students who indicated that the academic level of my lectures was “high” all had a background in physics or “other”, which in this class meant computer science or mathematics. This evaluation was not satisfactory, as it appeared that in my efforts to make the biology lectures accessible for everyone in the course, I lost more than half of them, since 54% reported that the academic level of the biology lectures were unsatisfactory in one direction or the other. The physics lectures suffered from the same problem, with 31% of the students reporting that the level was “high” or far too high”, and 31% reporting it was “low” or “far too low” (Fig. 15.2).

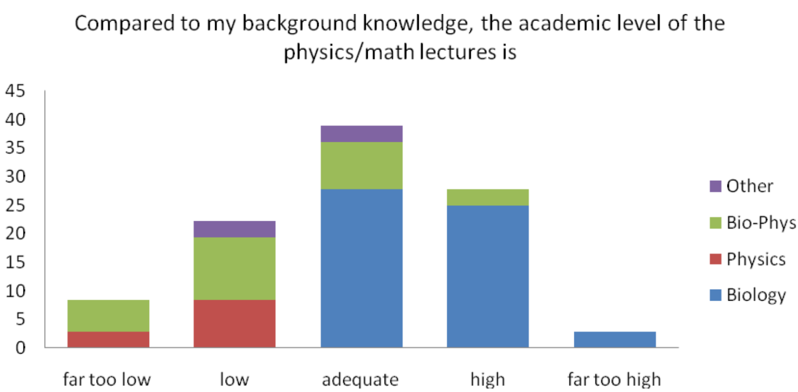


Fig. 15.2. Midway evaluation of the physics/maths lectures.

Does the varied educational background of the student body in this class make it an unattainable goal to give lectures from which everyone can learn from? Do we need to split the class and teach the biologists physics and the physicists biology? We rejected the latter option because separating the students to teach them different things is not likely to increase communication and collaboration between them.

In my opinion, the key to good lectures in this course will depend on more team-teaching between Namiko and I, so that the interdisciplinary curriculum is presented in an interdisciplinary way. Namiko and I need to develop the lectures together, incorporating the mathematics and the biology into coherent entities, rather than requiring the students to construct a multidisciplinary understanding of the topic by assembling knowledge from strictly additive disciplinary lectures themselves. From the beginning of the course, Namiko and I had tested our lectures on one another before presenting them to the students, and always attended each other's lectures. But we increasingly made an effort to teach each other the subject matter for each topic, while the lectures were still under development, thereby making them less disciplinary, and taking each other's intended learning objectives into consideration. This approach seemed to remedy the situation somewhat, since at the end of the course, 64% of the students found the academic level of the biology lectures appropriate, and 56% of the students found the physics/maths level appropriate (Fig. 15.3).

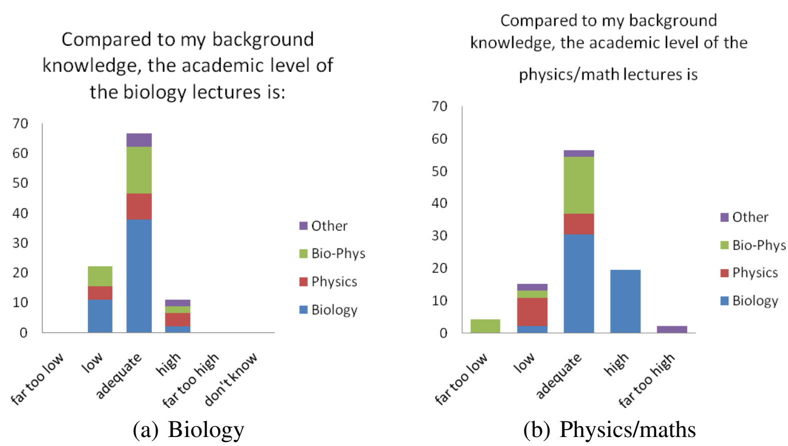


Fig. 15.3. Final evaluation of the biology (a) and physics/maths (b) lectures, respectively.

It is clear that we still have ample room for improvement of the lectures. Ideally, I believe that the lectures for this course should present the material in a way that neither the biology nor the physics students have seen before. At the very least, all students should feel that they got a fresh look and a new perspective even on familiar material. This can best be achieved by investing more time into integrating the maths and the biology by Namiko and me prior to presenting it to the students. However, as also pointed out by Gross (2004), preparing team-teaching with faculty from other disciplines takes much more time than teaching a solo lecture. The experience we have gained from giving the course once, especially attending all of each other's lectures, and assessing the students performance together at the exam, certainly provides a good starting point for collaborating to improve the lectures in 2011.

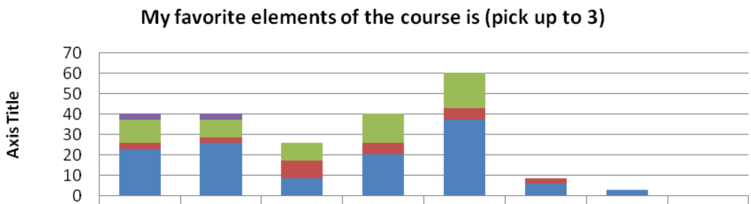
Teaching activities to promote interdisciplinary communication

The course contained three teaching activities aimed at promoting collaboration between the students, which were teacher-controlled to different degrees. First, the weekly classroom discussion of the articles which Namiko and I led together. Second, weekly group exercise sessions, where a group of four students, ideally from different backgrounds, had two hours to solve three or four problems based on the content of that week's curriculum. Third, an oral presentation of an assigned article prepared by each student group, which had to be approved in order for the students to qualify for taking the exam.

We feel that the group exercises were generally very successful. To get the right distribution of educational backgrounds, Namiko and I divided the students into groups. We found that the students were generally enthusiastic to teach each other the knowledge needed to solve the problems. In the students' rating of which teaching activity they favoured, the group exercises took first place (Fig. 15.4).

It is my conviction that almost all the students reached the intended learning outcome of being able to discuss scientific ideas with peers from other disciplines, and gaining new perspectives on material from their own discipline. This assertion was confirmed by the students' evaluations, where 78% agreed that the group exercises increased their understanding of the course material (Fig. 15.5a) and 70% agreed that mixing students with different backgrounds in the groups enhanced their understanding of the course material (Fig. 15.5b).

It was our impression that the more student-centred activities worked better to promote the students' communication skills. My reflection paper discusses my work with my pedagogical supervisors to make the classroom article discussions less teacher-focused and more student-centred, so I will not discuss that here.



	The Monday biology lecture	The Monday physics lecture	Reading the assigned paper	The Wed. paper discussion	The Wed. group exercises	The multiple choice test	Another part (please specify)	No favorite elements
Other	3	3	0	0	0	0	0	0
Bio-Phys	11	9	9	14	17	0	0	0
Physics	3	3	9	6	6	3	0	0
Biology	23	26	9	20	37	6	3	0

Fig. 15.4. The percentage of total students who picked the indicated activity as one of up to three favorite course elements.

Of the students who were neutral or disagreed to the first statement, several had commented that they lacked a verification of their answers from the teachers at the end of the group exercises, as they often had doubts as to whether their group had solved the exercises correctly. We did attempt to discuss the groups' results with them before the end of each class, but it is an important point to which we will pay greater attention to next year. The other disagreements were from a group where we lost the diversity early on, as the physics-oriented students in that group dropped out of the course. The students in that group commented that they had not really gained the full interdisciplinary experience they had hoped for, because the group consisted of solely biology-oriented students. Naturally, this situation should be avoided in the future, but we were glad to know that the students considered it a disadvantage to not be mixed with students of different backgrounds.

Assessing a diverse group of students

There are some special challenges associated with designing a fair exam for assessing a group of students with very different prior knowledge. First,

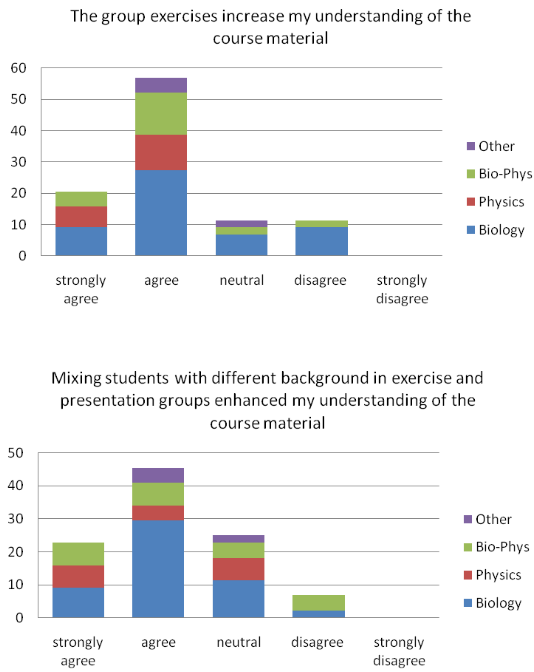


Fig. 15.5. The percentage of students who picked the indicated answer in the final course evaluation.

it is crucial that the assessment be criterion-referenced rather than norm-referenced, both because of the better educational logic associated with criterion-referenced assessment (it involves judgment of the performance rather than judgment of the people (Biggs & Tang; 2007)) and because norm-referenced assessment becomes less meaningful the broader the distribution of specific skills is among the student body. Second, there is an increased risk that less confident students will doubt their ability to perform well in the exam in a course like this, because it is clear during class that some students have a lot of specific knowledge about topics that might be completely new to others, and this doubt can create a negative learning climate. Third, since interdisciplinary communication is among the most important intended learning objectives for this course, the exam should ideally test this skill. Fourth, the exam should be designed so that no educational background provides a specific advantage or obstacle to success.

We designed an oral exam, which we think fulfils these criteria to a large degree. In the exam, the student draws one of the eight topics from the course, and has ten minutes to present this topic, after which the censor and examiner asks questions from the other seven topics for fifteen minutes. The students were given the specific exam questions for a given topic in advance, on the Monday of the week that dealt with this topic. Our reasons for revealing the exam questions this early were twofold. First, it clarified what the students are expected to know at the exam, and we think this served to decrease the doubt that less confident students might have about whether they are able to perform well in the exam. Second, it gave the students a chance to discuss the questions with their peers during the group exercises, as well as outside of class, and come up with answers that satisfied students of different educational backgrounds, which in effect meant coming up with answers that cover the perspectives of multiple disciplines.

Namiko and I put a lot of effort into constructing the exam questions every week, to assure that approximately equal amounts of our two disciplines' knowledge was required to satisfactorily answer them. We were both present for all the exams. During the exam, we took turns asking the student questions, and afterwards we independently assessed the student before discussing and agreeing on the grade. In nearly all cases, we agreed completely on the grade that the student should receive, and in the cases where we did not agree, we were never more than one step apart on the seven-step grading scale, and were able to reach consensus within a couple of minutes. Assessing students with different backgrounds can be a challenge when the faculty, like us, is not truly interdisciplinary, but represent two different disciplines. However, I think we succeeded in assessing the students fairly. The distribution of final grades is shown in figure 15.6.

The grade distribution shows no obvious bias towards student of a particular educational background. This distribution, together with our very positive personal experience of the students' collective performance at the exams, and their generally positive oral feedback, leads us to believe that the exam form is appropriate for this course. Thus, we intend to carry on with this form of exam, although 51 oral exams in one week represented a great commitment from the teachers.

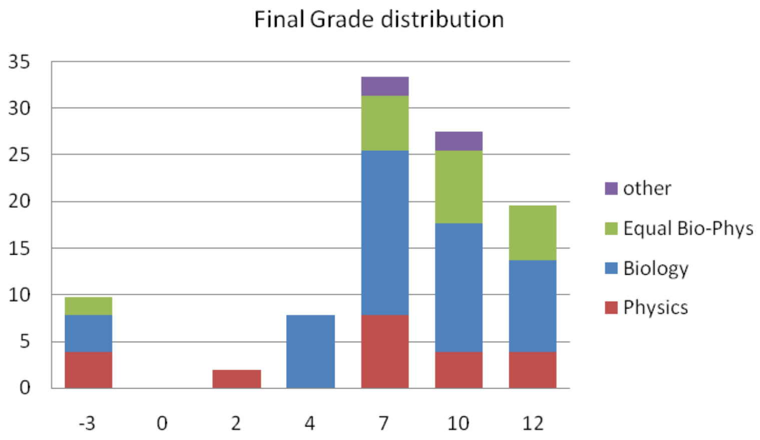


Fig. 15.6. The percentage of students receiving the indicated grade is indicated on the Y-axis.

Part IV

Evaluation and redesign of an entire course

16

Course learning objectives, teaching activities and constructive alignment assessment in sensory and consumer science

Derek V. Byrne

Department of Food Science, LIFE, University of Copenhagen

Purpose

It was my intention to assess the impact of Intended Learning Outcomes (ILOs) via student interviews overall for a Sensory and Consumer Science Course (course no. 270030), where my role is co-ordinator, and then in specific terms to look at ILOs for my own teaching in terms of teaching and learning activities (TLAs). Via this, I endeavoured to assess if the course was constructively aligned. In addition, I will touch upon the exam as a driving force to ILOs and students' perception of constructive alignment of the course.

The present investigation was inspired by Biggs (1996) and Biggs & Tang (2007), who indicate that to assess correctly if constructively aligned teaching and assessment exist there are four stages of assessment to be considered:

1. ILOs investigation
2. TLA with respect to ILOs
3. Assessment tasks (theory and project, about achieving ILOs)
4. Exam and grading (face-to-face, its importance to ILOs)

The following were then the aims in the matter of the interpretation of results in this project:

1. Alignment of course in itself – in students' minds and in coordinators' mind from focus discussions and questionnaires with students
2. Alignment within the total education (a comment will be made with respect to this and changes on the horizon in our course portfolio)

This was a very useful exercise concerning this course from my perspective, as our group has an ever expanding portfolio of courses at all levels and it is a continuing challenge to ensure that the newer courses and the older courses are aligned between and within themselves such that the totality of the sensory education at LIFE makes sense to students who dip in and take single courses or to those who take the courses consecutively, thus ensuring that overlap and repetition are kept to a minimum. Rather, anyone arriving for the first time can come up to speed in a reasonable amount of time, and a coherent education results in useful persons for the demands of the world of sensory science.

Individual project description

An initial problem definition, together with a preliminary project definition

- Assessment of existing overall course ILOs
- Assess ILOs from two main TLA techniques used, i.e., lectures versus active learning sessions
- Assess the course alignment overall

Formulate problem definition as a basis for structuring the working process

As course coordinator and having run this course for a number of years, I am very interested to understand the “success” of the course as it has been judged highly over the last few years by the students and academic teaching committee at LIFE. The simple questions are: Why is it judged successful? What is successful about it? and whether there is room for improvement in the achieving of ILOs via better constructive alignment.

Layer aim in relation to the present course

1. To determine overall if the ILOs in the course description as presented to the students are in fact met and to what degree - student interviews
2. What type of teaching method best contributes to ILOs of my own teaching on this course, thus a comparison of lecturing versus active learning will be made - student interview and group discussion

3. In addition, a commentary will be made with respect to whether the course is in fact constructively well aligned within itself and in broad terms, within the sensory study programme.

Required outcome

Each problem must contain a reasonable answer to the final problem definition with the involvement of relevant theory and circumstances. Thus, concerning guidelines for individual projects, the chosen project may, for example, discuss one or more (typically more) of the following topics:

- Intended learning outcomes and key elements of the course
- Reasons for the choice of the various teaching methods
- Student evaluation of the teaching
- Assessment of the students (exam)
- Alignment of the course

On the whole, it is not the intention of the project to achieve a wall-to-wall coverage of all aspects of your teaching. Rather, the intention is to focus on a problem which is in your opinion important to discuss.

Thus, I took two key issues into account: ILO/TLAs and to a minor degree the exam as a motivation for views on ILOs and TLAs in relation to understanding Constructive Alignment (CA) within the course.

Course background

Course objectives

The objectives of the course are to teach the students the basic principles of sensory theory and practice as well as consumer-choice behaviour. Moreover, it is a key objective of the course to give students a practical and applicable view of sensory and consumer science via a group project carried out across the course period.

The Sensory and Consumer Science course is a course for Bachelor students (earliest possible year after three years) and for Master's degree students, and it is taught by the Sensory Science group of the Department of Food Science at the Faculty of Life Sciences at the University of Copenhagen. All teaching takes place at LIFE, Rolighedsvej 30, 1958 Frederiksberg C.

Sensory and Consumer Science took place in block 2, which was from 15 November 2010 to the end of January 2011. Teaching took place every Monday afternoon and every Wednesday morning and afternoon for nine weeks (structure C). The course is worth 7.5 ECTS.

Course content and structure

Core competences achieved

According to the course description presented to the students online and in the course compendium, the following are the core competences the students will obtain from active participation.
Competences obtained within basic science:

- Knowledge of the different human senses and psychological concepts and theories
- Understanding of the basic anatomy and functioning of the human senses

Competences obtained within applied science:

- Comprehending theories of consumer choice behaviour
- Applying principles of sensory and consumer testing methodology
- Applying principles of experimental design and statistical evaluation of sensory and consumer data

These are generic and were assessed as part of the project: Did these make sense to the students and did they give them a clear idea as to the ILOs of the course?

Monday afternoons were dedicated to project work while Wednesday mornings were dedicated to traditional lecturing while Wednesday afternoons were focused on exercises and practical demos.

The course is structured in a holistic manner starting with lectures on senses, moving into the area of sensory methods; the data analysis of sensory data generated and how the senses are important in the consumer realm and in terms of sensory marketability. The course's holistic structure is underpinned by a practical project which practically underpins the course structure and the structure is also given context by lectures related to ongoing research and in industrial applications.

Specific subject areas of teaching/learning (ILOs)

The Sensory and Consumer Science course consists of lectures, theoretical and practical exercises as well as a group project which follows the course content closely. Thus, the students apply the theory in practice over the period of the course. In addition, excursions are included. In the lectures, introductions, overviews and demonstrations are given related to several areas. The following are the ILOs as they are presented to the students in the course description, also the project context of the lectures and exercises are presented:

- Philosophical aspects of sensory and instrumental measurements
- Anatomy and biology of the human senses
- Theories within experimental psychology and consumer behaviour
- Sensory science from a broader cultural, historical and societal perspective
- Methods for measurement of sensory properties
- Relationships to chemical and physical properties
- Consumer choices and affective evaluation/preferences
- Experimental design and statistical evaluation of sensory data for discriminative and descriptive testing as well as linking sensory, consumer and instrumental data.
- Examples of applying sensory and consumer methods in development of (healthy) foods in food industry

Theoretical and practical exercises include hypothetical sensory problems and testing of sensory methods in practice. Through the project work, students will learn how to apply sensory theories and methods. During the excursion, applications of sensory science in the food industry and research will be illustrated.

These were more specific definitions of ILOs and to give an idea of where the course can have an impact on students' total education and their working lives after university in general. This aspect was also addressed in the focus group and questionnaire in terms of a step in assessing alignment of the course within itself.

Assessment and exam

Before the students can take the examination, they must attend the theoretical and laboratory demonstration exercises. In addition, the project report must be completed and passed in a short oral project examination to qualify for attendance at the final written exam. Thus, full attendance and involvement in the project group work over the course period is required.

The examination is a four-hour written examination and it takes place at the end of the course period. The relevance of the exam, in terms of the students' view on how ILOs were understood and how they should be presented, was in general terms addressed in relation to TLAs and overall alignment.

Literature

The course has a recommended text book: Meilgaard et al. (2007). It is a well established text book in the area and specific chapters are pointed out as related to specific lectures and exercises. Moreover, the book serves as a reference source for all the main issues in sensory and consumer science thus, it is pretty much an encyclopaedia that the students have in their hands at all times throughout the course. It is a valuable reference source for them during the lectures, exercises and project work.

In addition, a pensum list of articles related to specific lectures is utilized to supplement the book, which shows the course description in more detail in terms of ILOs, TLAs and alignment than presented on the LIFE homepage.

Finally, the lecture and exercise slides are placed online for the students as relevant to the exam. Additional materials can be found via library, project supervisors, science direct etc. and are at the students' discretion most relevant in relation to their project report.

Methodology

Students

In total 32 students from various nations, including Spain, Germany, Denmark, Russia and France, participated in the course. These students were randomly divided into project groups with four students per group. Of these groups two sets of four people were selected at random to participate in a focus interview. Prior to this, they were asked to fill in a questionnaire.

The students selected for the focus group interview were:
Group 1

- Informant DK1: Student from Denmark, female, Bachelor in Nutrition and Health
- Informant DK2: Student from Denmark, female, Bachelor in Food Science
- Informant Ger1: Student from Germany, Bachelor in Food Business
- Informant DK3: Student from Denmark, Bachelor in Nutrition

Group 2

- Informant SP1: Student from Denmark, female, Agricultural Engineering; Environment
- Informant Ger 1: Student from Germany, female, Bachelor in Nutrition
- Informant Ger 2: Student from Germany, Bachelor in Nutrition
- Informant Ger 3 Student from Germany, Bachelor in Nutrition

Questionnaire

The pre-interview questionnaire evaluated student background with regard to nationality and education. It identified student views on advantages and disadvantages of issues in relation to ILOs/TLAs and alignment, and evaluated the students' perception of the various topics by using rating scales from "strongly disagree" to "strongly agree" for the majority of questions and open answer possibilities for additional questions.

Focus group interview

A set of questions was worked out beforehand with the intent to have an interview build up as a conversation. In order to achieve this, I applied a certain degree of freedom to the order of the questions, to the wording and to leave out questions that appeared redundant during the conversation. I followed a few simple principles during the interview (Kvale; 1997; McCracken; 1988):

- Listen – I tried not to get involved and share our own experiences, because this might influence informants and they could use what you say to guess what you would like to hear, rather than what you need to hear.
- Pose short and clear questions – the interviewee may lose the point of the question.
- Remain neutral, enjoy the interview – look interested, smile and keep eye contact.
- Use probes and prompts – refer to elements of the interview
- Take a full record of the interview – the interview was recorded with a video camera

In order to fulfil the requirements of these principles, I structured the interview in the following parts:

Introductory questions. The students selected for the focus group interview were asked to briefly answer the following questions: “Where do you come from?”, “What is your education (bachelor/master)?”. I also informed them about the nature of the interview and the areas we would address during our discussion. The idea behind these introductory questions is to make the participants of the focus group interview more comfortable and to give them time to tune their mind to the next series of questions. The students will hopefully also understand that they are not going to be evaluated on basis of what they will answer. In order to emphasize this, I underlined that the information gained during the interview will be useful to improve the course constructive alignment at University of Copenhagen and that in the near future, other students will benefit from this.

Elements of the interview. To assess the students and gain information regarding our purpose and to verify our hypothesis, we decided to structure the focus group interview in three different elements: grand-tour questions, floating prompts and planned prompts. These elements were inspired by Leech (2002) who stated “In an interview, what you already know is as important as what you want to know. What you want to know determines which questions you will ask. What you already know will determine how you ask them.”

The focus group interview was planned to be of one-hour duration and aimed to cover the following three topics:

Learning objectives (ILOs). The aim was to determine what the learning experiences from the course were for the different students. I explored if they felt they were learning in general and if so why. In this respect, I asked about their understanding of what the concept of ILOs were in general and based on this: Did they understand the ILOs of the course per se? Then in specific terms the ILOs of the individual lectures and of the project. Moreover, in this respect, I asked if it was down to individual teachers’ style of lecturing, whether they presented ILOs up front or not that was a contributing factor to understanding and learning. Also, was the exam a motivation to determine what the ILOs were? Finally, how could ILOs be communicated better in the course?

Teaching and learning activities (TLAs). The aim was to determine if the students viewed the teaching methods employed in the course as useful in terms of giving them a sense of having achieved the ILOs. In this respect, lecturing versus exercises were explored as well as the use of a parallel practical project.

Alignment. The aim with this aspect of the interview was to discuss with the students if they believed the course as a whole worked. In that, the ILOs were obvious from the TLAs employed. In addition, the aim was to determine if the students saw the course as aligned with their total education and if it fitted with what they viewed as job prospects after they had finished university.

Analysis and findings

State of the nation

The course evaluation process at IFV-LIFE involves an online questionnaire on Absalon for the students to assess the course, content, teachers and structure. This is collected by the coordinator, synopsised and discussed in an open session with the full class of students. The results of this process are written in a report and submitted to the study board who make a judgement on its content and recommendations for areas of improvement. For the last five years, the Sensory and Consumer Science course has run and each year has received the highest grade, an A rating.

In broad terms, all issues have been actively sought out and actively addressed in each subsequent year. However, I wished to learn more about why the course is considered good by students and how it can be improved even further. This came from the knowledge that the individual teachers' teaching techniques and abilities varied widely and aspects of the course structure could still be improved in terms of alignment with timing for learning as the course is progressive in its knowledge building.

Focus group interview questionnaire

In explanation of the analysis of the focus group interview and questionnaire, the focus group responses were analysed according to key responses in relation to the main aims of the project, namely ILOs, TLAs and other in relation to CA.

From the individuals in each group we derived demographic information on each student. More importantly, the questionnaire in reality was used to cross check the focus group answers with the general consensus via questionnaire, thus, what one might refer to as an objective validation of the group's opinions used. In this respect, it was clear that the answers in objective terms matched those achieved in the more subjective surroundings of the focus group. After experiencing the interview and analysing the recording, we structured the analysis within the topics of A) ILOs, B)TLAs and C) Alignment.

The questionnaire

Key points about questionnaire would be the following based on the three key areas of focus.

(A) Intended Learning Outcomes (ILOs). The ILOs were scored high for the course in general at four, but with an additional category five their appears to be room for improvement. In this respect, it appears that ILOs for and from the practical project is much higher than for the lectures on the course in general (Fig. 16.1). Thus, this is a major contributing factor to the overall less than perfect ILO score for the course. In addition, the individual teachers came under scrutiny with respect to their ability to communicate ILOs. Some were better than others, again a contributing factor to an overall score below full marks. Finally, it was clear that the pensum list could be improved with respect to ILOs, once it was understood what the ILOs were from the introduction, but the existence of many articles and papers in addition to the course book was not appreciated. They appeared not to see clarity in the intended learning possibility from the papers. It would be my guess that these students at their level are not used to reading research articles from the perspective of learning and as such cannot, figuratively speaking, see the wood from the trees, the wood, of course, being the ILOs. An additional question in terms of ILOs was in relation to recommended courses indicated as useful in the course description as good to have attended prior to the Sensory and Consumer Science Course. The majority indicated that this was a useful thing to have had prior to starting the course, and it is most likely a reason for a lack of understanding of ILOs for a number of students as in reality some have zero background and do not even understand the basic terminology used in the course. This is an unfortunate reality of education at LIFE; that it is not allowed to impose compulsory courses as a prerequisite. This is an unfortunate policy since those that have the background become frustrated at the pace of the course as we have to include the basics to bring all along. It does not make way for a level playing field to begin with, so to speak, but hopefully by the end

of the course, all are somewhat at least able to pass the exam, and what we in fact have found is that we achieve a solid distribution across the students each year with some excelling and some just passing with the majority in the mid-plus range.

(B) Teaching and Learning Activities (TLAs). In general, the students scored the level of learning which they believed they were achieving. If they are as high in this respect, then the use of interactive TLAs is a better contributor than lectures. Also, it was apparent that the level of learning was very much related to the ability of the individual teachers in terms of their teaching skills in achieving a high understanding of the lecture ILOs (Fig. 16.1).

(C) Alignment. In terms of questions relating to the overall alignment of the course in the students opinion, the course scored highly. In addition, when asked about the course's alignment with the students' education in general, it was very high. This was not surprising as all students were in some way involved in food science, however, it was interesting that the majority indicated "nutrition" as a specialization which has only in the last few years become closely linked with sensory and consumer science. With this, I mean from the perspective that nutritionists now realise that no matter how "healthy" a product is perceived to be, it will not be eaten if it does not taste good – a simple but very true fact. People may eat something once or twice but what is needed to influence health with food is mass adaptation to products such that they become the new norm. Many students went as far as indicating that the course was part of the master plan they had for their education from the start. It has to be said that some disagreed totally with this also.

Finally, a point that is worth highlighting, after all is said and done, the students indicate that they liked the sound of the course very much, thus, it is a good idea in the course description to make courses sound good to get students to participate.

Focus group interview

In this section, I will present the key conclusions from the points made by the students in relation to the grand tour questions of the focus interview which shed light on ILO/TLA and Alignment. Furthermore, a link is made to the indications of the questionnaire (previous section) as reinforcement of "validity" in terms of an independent view versus an opinion in a group setting.

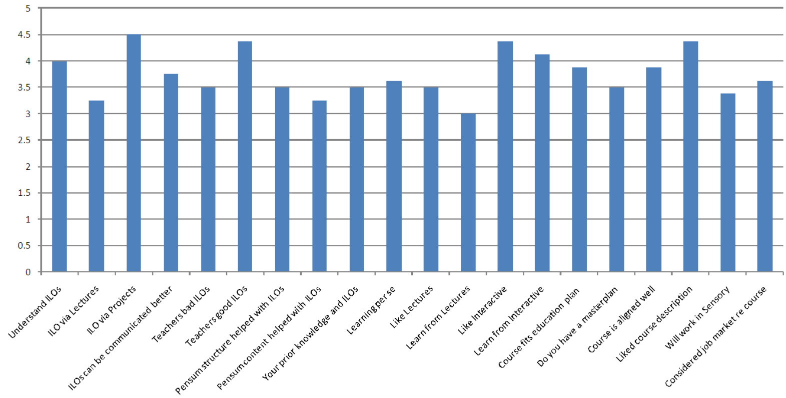


Fig. 16.1. Mean responses to initial questionnaire by focus group participants.

Most importantly, here also the students suggested methods based on their experiences of teaching as to how they believe any issues could be improved. This is, of course, important in that sometimes we as teachers cannot see the wood for the trees and the most obvious solutions can be missed.

I summarize the main conclusions as text and include quotes only where appropriate.

Note: The individual questionnaire is linked directly to the focus areas of the interview, in terms of objective scoring of key issues regarding ILO, TLA and alignment as discussed in previous section.

A. ILOs. Grand Tour Question, focus: clarity of learning goals. They were asked specifically why they chose the course, were they clear as to what they were learning and did they feel they were learning something? The following is a synopsis of the main points raised in the conclusion on ILOs:

- Structure: It is very well-structured
- ILOs about lecturing versus exercises, exercises work best, but they can see the merits of lecturing
- Project works well as an underpinning and focal structure for the learning across the course
- Timing: The course needs a little tweaking in terms of timing - early in the course some lectures did not fit closely enough with progress on report, there

was a slight lag in that they would have begun on the project with the issues that came two days later in the course. In previous years, this has not been noticed, but via this interview process it was clearly an issue. Particularly so for one third of the students who indicated that they did not have all the recommended courses prior to this course.

- Attention span: A critical issue linked closely to the previous "timing" issue discussed was a tweaking needed of the ordering of the daily schedule to ensure attention was not lost after a long day of class work on Wednesdays, where lectures and exercises mainly take place in the same room. This by default will also help with the lack of alignment of the course work in the first two weeks of the block with the progress on their practical project. Such that the lectures precede the project work, as well as there are no full days in the classroom. Project work is carried out in our various labs, but involves preparation, consumer testing etc. so it is very varied and interesting and a break from the classroom.

B. TLAs. Grand tour question, focus: reasons for lack of clarity in ILOs. Was it the individual teachers or the style of teaching? How to best improve any lack of clarity? Was the exam a driving force and did any lack of clarity cause frustration in this respect? Conclusions on TLAs:

- Teaching good overall, some better than others and this has implications, of course, for the clarity of the individual lecture ILOs – to improve, send guidelines to all teachers on how the ILOs of their lectures should be displayed.
- Also break down the lectures in the compendium in terms of ILOs, such that one has a full overview of each lecture's ILOs linked to the main subject areas as presented in the course, plus a link to diagram of main course areas. Students indicated that it was a good idea to improve the compendium course overview.
- Teachers should focus on the point and not waffle all over the place. This was countered by by the opinion that it is also nice to get the broader view. The first point was from a student who was exam-focused so it was no surprise also during the course that she asked about ILOs.
- Teaching formats; lectures are not as interesting as exercises and demonstrations, but in agreement with that fact comes through lectures, but understanding of the facts in many cases comes through linked exercises.

C. Students' view of alignment of course. The aim here was to get the students' view on the constructive alignment of the course such that I as a coordinator could make a judgement on its overall alignment. Again, to try to validate my interpretation with the views of the students. Thus, the linkage of ILOs and TLAs and course structure were the main focus of discussion. Grand tour question 1, focus: Do you feel that the course works well for you in its format? Do you feel it functions well in terms of its make-up? Does it function well for you in your overall education now that you are doing the course? Do you know what type of job you might get afterwards? Can you see where sensory is important now? Has the course lived up to its interesting description?

Conclusions – alignment – students' views

As already pointed out, the alignment about timing of initial lectures needs sharpening, but then the students indicated they were on a roll after two weeks and it all became good. This year (2010) was special as all were very quick in their project progress, more so than in previous years.

The ILOs and TLAs were okay for them, but, of course, they would like more activity and less classroom. Also, the project was a very effective frame to fit to the ILOs for them, in that way they could see what they learned work clearly in practice, i.e. how to train a sensory panel in theory, then do it in practice. An interesting exercise is to get the theory to work on real people in practice and it is not easy.

In terms of a discussion of whether this course part is part of a master plan and whether it fits in with their overall education: Some agreed, some totally disagreed. In conclusion, the students may have been a little young, as third-year BSc/first-year MSc (who may have a stronger view as to the course's relevance) to really comprehend this question, but it was interesting to ask as it gave an idea of the motivation for choosing the course, such that we knew it was not just because they liked the sound of the description as was discussed previously.

As a conduit to the overall education fit, I asked if they had opinions on the type of jobs that they might get as a result of this type of course and focus in their education. It was clear that the Danes had very clear and precise views on this, the Germans were much less clear. However, all of them indicated that it was much too early to consider jobs seriously concerning their education as they were having so much fun at university. We all, of course, recall these happy go lucky times.

In terms of the overall question: "Has the course lived up to expectations?", the response was very positive and the students indicated that they became more and more interested and drawn in as the course progressed. To the point now they indicated that are becoming annoyed to as dinner companions as they discuss the various sensory aspects of the food they are eating and the pros and cons of these with their dining partners. From my perspective, we could not wish for much more in that we have converted them to the sensory path and this is, of course, where we will get our best PhDs from in the future.

Perspectives

Here is, to make an overall conclusion from the above, my view as coordinator of how well the constructive alignment of the course works based on the systematic analysis of the questionnaire and focus interview conclusions as determined.

Identification of some key issues:

1. Lecture is the standard in most countries and is accepted, but it is not "entertaining" enough. Is this a reasonable view, is education and learning about entertainment? To a degree for certain; the trick is to strike a balance between structure, information, teaching techniques and enabling learning. Thus, breaking the lecture up with a series of tasks, discussions and small exercises has proven to work very well for me on course teaching. It is nice now to know I do not have to talk for 45 minutes during a 'lecture'; this was always a daunting task and the realization that this is perhaps not a good idea in itself was a welcoming relief.
2. Interaction is better than lecture, but do students really learn from one over the other? A clearly aligned combination with appropriate timing appears to be the best solution. The present course will benefit a lot from this information from the students.
3. ILO learning goals are reasonably well understood, but should be integrated better, across the course description and linked more clearly to the compendium and individual lectures and back via project.
4. Teachers should be more coordinated and have a standard format for their lectures in terms of ILOs up-front and make sure that these are clearly linked to the overview of the course in the compendium and initial lecture on course content given on day one. This will be an active issue for next time where we will send out a set of suggested guidelines with the constructive alignment idea described for the lecturers.
5. Alignment is very good in terms of a mix of lectures, exercises and practical project work. A slight rethinking of the focus of the days is needed due to fatigue, so one half day of lectures on Monday, one half day of exercises on Wednesday and afternoon Wednesday project work.
6. Timing of lectures needs rethinking in terms of when they are best presented. In relation to this, the reordering in point five would also help a lot in that they are lectured and do exercises just before they work on that part of the project,

most importantly, in the first two weeks of the course only, they find a balance after that.

7. The course book needs to be looked at in terms of lecture structure. The compendium's function now is papers linked to lectures, whereas it should be papers linked to exercises linked to lectures such that the alignment of the ILOs is clearer.

17

Preparing students for industrial quality control of medicines while keeping a problem-based and research-oriented learning environment

Michael Timm

Department of Pharmacology and Pharmacotherapy, FARMA, University of Copenhagen

Introduction

The MSc education in Pharmacy (Cand. Pharm) at the Faculty of Pharmaceutical Sciences (FARMA), University of Copenhagen, is composed mainly of compulsory courses. Currently, only one semester at the end of the education can be used for elective courses. As a consequence, the elective courses and the final Master's thesis comprise the only specialization the students can obtain within the basic education. Therefore, students that are enrolled in the elective courses have fairly extensive background knowledge and are all (with the possible exception of guest students) at similar academic levels.

The elective FARMA master course "Quality Control of Medicines – microbiological and immunological approaches" (subsequently abbreviated QCM) will have to be transformed from a 5 ECTS intensive course to a 7.5 ECTS block structure course. This will result in a major transformation of the entire course schedule and learning activities. The course was in its original form mainly a laboratory course with focus on methods used for testing medicines for microbial contaminants. The methods used in the course were very diverse and included past, present and future techniques for detection of bacterial contaminants, all with a primary focus on research-based uses.

The transformation of the course in to a block structure requires an intensive restructuring, since the course requires cell culturing and bacterial preparations, processes that should preferably be attended to daily. Since restructuring is needed, the group of teachers responsible for the course decided that this could represent a golden opportunity to slightly alter the course content to include a more industrial-orientated approach. An initial analysis of the course has helped to identify segments of the course where alignment may be insufficient and where the “Intended Learning Objectives” (ILO), ”Teaching/Learning Activities” (TLA) and “Assessment Tasks” (AT) could be improved. It is the overall aim of this work to implement some of the previously identified suggestions for improvement and to evaluate the new course as a whole. The evaluation should include both the teaching group associated with the course (four scientific and two technical administrative staff members) and the students (17 students are enrolled in the course). The new course platform was offered for the first time from November 2010 to January 2011. It was decided by the teaching group associated with the course to make the teaching problem-oriented and to include both techniques and personnel from the industry relevant to the course.

Purpose

This work is conducted in the effort of designing and conducting a course at FARMA that joins:

- Conductance of quality-control experiments of pharmaceuticals according to the currently approved methods for pyrogen testing as used in the industry.
- Independent student work based on “problem-based learning”
- Introduction to novel and research based methods
- Student ability to understand literature within the art, defining problems, preparing protocols for experimentation and apply critical evaluation of results obtained.

It is the overall objective to design the course in a way that appeals to the students so that they find it interesting and relevant, while still keeping the level of education and industrial applicability at an advanced level.

Deliverables

To achieve the overall goal of the project and to obtain valid course evaluation I believe the following nine deliverables are necessary:

- Overall logistical planning of the course determined.

- New course material designed (instruction manuals etc.).
- Revised format for student guidance in the laboratory developed.
- Teaching of the students by research-oriented relevant personal.
- Teaching of the students by industrial relevant personal.
- Student acceptance and consent of the format chosen.
- A questionnaire for student evaluation of the teaching.
- Interview with the teaching group.
- Interview with students.

Success criteria

In order to evaluate the course transformation as a success we believe that it is essential to meet the following success criteria:

- The overall design of the course (the new course material, the logistical planning, the PBL format and the choice of assays) allows industrial and research-based experiments to be conducted along with theoretical considerations, self-reflection and independent study as evaluated by students after the course.
- Students feel that they have a problem-based approach to the questions raised in the course material but still feel that the guidance is adequate. Furthermore, the students' display in-depth topic understanding, can read and understand scientific literature within the field, and have a critical approach to own results which is evident in high marks at the final exam.
- Students are educated in quality control of medicines as conducted in the pharmaceutical industry and novel research methods for quality control of medicines by both scientific and industrial personal. And the students rate the course as relevant both in respect to industrial and scientific research methods and see the connection.
- Interview with teaching group and students, rate the new course as relevant and well-proportioned AND suggests future improvements.

Reflections regarding the teaching format used in QCM

The course in QCM has traditionally been a laboratory focused course. The techniques taught on the course are the cornerstones in the industrial routine testing of medicines. Emphasis has never been on the industrial application of these methods, however, but more related to variants of the tests or alternate applications since this will provide more interesting results in a research and development setting. Moreover, the former curriculum has also included a variety of alternative tests that are not generally accepted by the authorities or the industry. The reason for this was to provide the students with insight into the research-based approach that we as teachers find fascinating and intriguing. Since this is an elective course, experience teaches us that the participating students are generally enthusiastic and have selected the course on the basis of a true interest in the novel methods we teach. However, only 13% of the students proceed with a research-based career (PhD) while more than 50% will be employed in the medicinal and biotech industry (Farma; 2007). Moreover, since approx. 30% of the postgraduates report that they work with registration, quality assurance or quality control (QA/QC) (Farma; 2007), it is far more likely that a course designed to meet the requirements of the industrial setting would benefit the students more in their future employments.

Education of students is, however, not normally based upon industrial needs or wishes. Nor would it be correct or desirable to exclude the novel methods from the teaching since they comprise the cornerstones of the research-based teaching that may be considered crucial for university studies. However, it could be rightfully argued that students may benefit from both the industrial and the research-based approach to quality control. It is also generally accepted that students will learn more easily if the applicability of the subject is evident.

Traditionally, the format for the course has been the much disputed "cook-book" format where students conduct the experiments according to the instructions of the lab manual. However, unrelated to the format chosen, the whole concept of laboratory teaching has been the subject of many investigations and review papers. In 2005, Hofstein and coworkers summarized many of these reviews by stating that, in general, the research in the area has failed to show simplistic relationships between experiences in the laboratory and student learning (Hofstein et al.; 2005). Hofstein also cites Gunstone & Champagne (1990) for claiming that "learning in the laboratory is possible if students are given ample time and the opportunities for interaction and reflection to initiate discussion" (Hofstein et al.; 2005). In the given setting of the QCM course, it is, however, not only relevant how the conceptual learning of the students is facilitated but also how we can best develop their "craftsmanship skills". The laboratory approach used in the course design is chosen not only to emphasize the theoretical knowledge of the textbook by using follow-up experiments but rather to educate the students in correct practical conductance of experiments. In order to test medicines for minute concentrations of contaminants, it is essential that the students themselves do not intentionally contaminate the experiments and that they learn to work with outmost precision and overview. This requires that the students are educated in correct techniques and good laboratory practice (GLP) something that can, of course, be studied in a textbook, but never fully comprehended or mastered before bering experienced in a laboratory.

With the obvious need for a hands-on approach to this course, we sought to design the laboratory part of the course based on industrial and regulatory applicability, but with the intention of keeping a research-based problem-oriented approach. Our initial considerations for the course structure is not unlike the one presented by Schulz and McRobbie in a 1994 study regarding a constructivist approach to science experiments (Schulz & McRobbie; 1994). Five major features guided their design of the laboratory teaching:

- Students' own ideas were elicited.
- Students' own ideas clarified/challenged.
- Application activities planned.
- Real life situations used.
- Time and space for student reflection and social interaction.

This study showed a statistically significant increase in learning when employing these major features in the teaching compared with the more traditional laboratory activities.

These major features also reflect some of the considerations we have made in the new design of the QCM course. We want students to play a central role in the design and evaluation of their own experiments while still keeping the industrial and research perspectives in mind. Therefore we have revised all but one exercise in the curriculum to include student planning and in depth evaluation of results.

Course design conceived for QCM

In the newly applied block structure the QCM course is placed in block 2, timetable B. This means that in 2010/2011, the course consisted of five weeks before Christmas break and three weeks after the break where the last week will be reserved for exams.

The general idea for the course design is that the first five weeks are spent in the laboratory and the last two weeks are spent with result evaluation and peer presentations. Furthermore, the last weeks will include original literature scrutiny and lectures given by specialists from the industry that are working with quality control on a daily basis.

For the practical part, the students are working together in groups of two. Each group receives two different pharmaceuticals that they are to spend four weeks analyzing using various assays. The last week is spent on a project of the students' own choice.

For the analysis of the original pharmaceuticals, students are not given any instructions apart from the question: "Can these products be released for patient use?" The lab manual describes four Pharmacopoeia-approved methods for microbial quality control (pyrogen tests) whereof we have facilities for conducting three of them and one alternative research-based assay. Basically, the block structure allows each group to have three days of lab time (Monday from 8 to 12, Tuesday from 13 to 17 and Friday from 8to 12) for each test and three days for an independent project.

Without the students' knowledge, the original drug products are divided between the groups in such a way that each group will receive one product which has been intentionally contaminated with microbial debris and one product that due to its formulation exerts interference with one or several of the assays.

It is, thus, the objective of the students to overcome the interference of one product and to correctly identify the contaminated product in relation to origin of the contaminant and the concentration of the contaminant.

It is intended that on the first day the students familiarize themselves with the new test and test their products s according to the general description from the lab manual. When they then experience the possible problems of testing some products directly (due to interference), they are to use the second day to refer to literature and to conceive ideas to overcome potential problems. On the third day, the students can repeat the experiment implementing their own conceived experimental designs. Students can, of course, utilize the experiences from the previous experiment in the next, and thereby increase the possibility of correctly identifying the origin and concentration of the contaminant.

If we were to relate the herein described course design to the five features described by Schulz & McRobbie (1994), we could relate the content to the five features in the following way:

> It is the overall idea that the students must conceive a way to get rid of the interfering substances in the medicines; furthermore students will have to adapt the experimental design of product testing in a way so that it will fulfil the requirements of the pharmacopoeia.

Based on the results of the first experiments, students' ideas to eliminate interference or improve detection limits will be discussed/validated with the teachers in order to verify that all relevant controls have been included and that the chosen format fulfils requirements. If not, students are encouraged to change the experimental design. (It should be noted that there are no teacher comments in regard to whether or not the experimental set-up will give the results intended. It is likely that the setup chosen by the students will not provide the desired results, this is however also considered a "positive/successful" outcome of the exercise).
Application activities planned in relation to above mentioned.
Similar to an industrial setting, the exercises are conducted as teamwork with the possibility of peer discussions. Real pharmaceuticals are used and the experiments are conducted more or less as they would have been conducted in an industrial quality control laboratory. Furthermore, the students have the overall (imaginary) responsibility for whether or not the product can be released to patients, an obligation that is identical to the one they will face in a future position in a QC laboratory.
Students will have ample time to discuss the results and future approaches on day two of an experiment. Furthermore, four groups of students will be working with the same technique and thus have time for joint reflection and social interaction throughout the days. At the end of the course, the two weeks of classroom teaching will include group work with opponent group discussion and peer presentation of the experimental design chosen and results obtained.

Considerations regarding the good PBL student and the good PBL facilitator

At FARMA, PBL or other variants of the minimally guided approach have been implemented for several years. The current use of PBL is highly dependent on the course and course director, but many compulsory as well as elective courses have PBL exercises included. If we look at the general characteristics of PBL, namely, that: (81) Learning is driven by challenging, open-ended, ill-defined and ill-structured problems. (2) Students generally work in collaborative groups, and (3) Teachers take on the role as "facilitators" of learning. One could argue that what some teachers consider PBL might be far away from this definition. The laboratory setting seldom supports truly open-ended, ill-defined and ill-structured problems since the equipment will always limit the possible ways and means of solving a problem. Moreover, it seems that even though teachers try to take the role as facilitators, most teachers who attempt to implement a constructivist approach end up providing students with considerable guidance (Kirschner et al.; 2006).

It is the overall aim to adapt a PBL-like format to the QCM course since the teaching group believes that the problem-based approach will encourage the students to undertake an indepth investigation in regard to the application and value of the various methods, while still focusing on the importance of learning the craftsmanship related to the techniques. With this in mind, it is highly relevant to consider how we can best facilitate a PBL-like approach to the course. One of the key aspects is to make students aware of the format and to let them know what is expected of them. Here we emphasize the fact that the students are given ample time to conduct the experiments since we expect that many students will find this format confusing and frustrating in the beginning due to the lack of guidance and poor prerequisites of the students. Likewise, the instructors have to adapt to the role of facilitators instead of teachers. This process is also expected to pose a considerable challenge.

Recognizing that it may serve little purpose discussing whether or not a laboratory course can ever fully fulfil the general characteristics of PBL, it may perhaps be more useful to look at the openness of the course. Using the four levels of enquiry (0: Confirmation/Verification, 1: Structured Inquiry, 2: Guided Inquiry and 3: Open Inquiry) we may be able to evaluate the degree of openness of the various exercises according to the Schwab/Herron levels of laboratory openness (Fig. 17.1).

LEVEL	PROBLEM	WAYS & MEANS	ANSWERS
0	Given	Given	Given
1	Given	Given	Open
2	Given	Open	Open
3	Open	Open	Open

Fig. 17.1. Schwab/Herron Levels of Laboratory Openness

The classic cookbook experiment would normally represent level 0 or 1 whereas the fully implemented PBL project would be a level 2 or 3 exercise.

Implementing the decided changes in QCM would result in a course structure allowing students to work with "one project". The objective is to verify whether or not two selected products can be released for patient use. The implementation of this project-based structure meant that we had to eliminate a few classical cookbook exercises and include a new method that was well defined in literature. Thus, the execution of the individual tests was still subjected to well-described protocols, but the format would have to be defined and altered based on the literature discovered by the students. This way, the otherwise well-defined problem with given ways or means, was now much more open-ended and allowed student speculation regarding assay setup and sample preparation. Therefore, compiling three or four classical cookbook experiments to one project both increased the level of openness and introduced a problem-oriented approach to QC problems much like the students are expected to encounter in their future professional careers. It is the intention that the Schwab/Herron model for laboratory openness should be kept in mind when advising the students and that this may support the transformation from "teacher/instructor" to "facilitator".

We, therefore, believe that the PBL-based approach fully supports the considerations we have made regarding the course. It is, however, an essential prerequisite that both students and instructors are fully aware of the requirements and limitations of the format.

Assessment

The course was originally assessed by an oral examination and it was early on decided to keep this format. It is, generally, believed by the teaching group that this allows more indepth discussions regarding choice of assays for quality control as well as supporting the possibility of student to relate critically to their own results obtained in the projects with greater detail and nuance. This examination form is believed to be well suited for the course since the key learning objectives are to conduct and to account for the theoretical aspects of a given method, but more importantly to assess the value and the results of an applied method to a given problem.

One problem in regard to this assessment format is that it does not take directly into account the ILOs related to the laboratory work. In the "course outcome", as defined by the course description point seven states that students should be able to conduct Quality Control as described by Regulatory Authorities. However, the practical experimental skills are not directly assessed in the final exam. It could be argued that the laboratory performance of the students is indirectly evaluated since the results obtained in the laboratory form the basis of their further reflections and evaluation. It is likely that the assessment format could take reflections done in the laboratory into account and results obtained to an even greater extend. One way would be to include an assessment of the final "quality control (QC) report" the students are to submit. This assessment could then count for a percentage of the grade. However, since the "QC report" is the final result of weeks of group work, assigning a mark to the report would require the students to list a responsible person for each section of the report (due to the Danish legislation regarding group examinations) and this division of tasks and responsibility between group members is not believed to benefit the overall objective of the course. Therefore, we decided to base the entire evaluation on the final oral examination.

One interesting alternative would be to make a final individual one-week project based on full implementation of the PBL format where students could harvest the experiences obtained in the foregoing weeks. This experiment could then result in an individual report that is evaluated by the seven-scale grading system constituting e.g. 30-50% of the final grade. This suggested evaluation form should allow students to perceive that their performance in the laboratory as well as their analytical and problem-solving skills are evaluated and thus improve the alignment of the course. Unfortunately, the limitations in available laboratory equipment preclude this possibility.

For the exam, the limited information in the lab manual, the QC report and all original literature presented during the course constitute the curriculum.

Results

Implementation of the new course structure in the laboratory part

With some obstacles, the overall logistical planning of the course was comprised in a way that allowed transition from intensive course to block structure course. Especially, the continuous cultivation of cells represented a challenge but the goodwill and flexibility of the technical staff associated with the course allowed the five weeks of laboratory work to be conducted in an orderly and meaningful way. However, limitations in the apparatus available did suggest that precautions may be relevant with a fully booked course (24 students instead of the 17 we had enrolled this year). It is the general impression from the teaching group that the new course material designed was suited for the purpose and that the high degree of openness did not intimidate the students. General discussions in the teaching group also revealed a common agreement that the aim to implement a constructive approach was, in part, successful and we believed that the direct guidance of the students was kept to a minimum. There was a general acceptance of students' ideas that were "outside the box" and students were in general encouraged to proceed with experiments even though the apparent chances of success were minimal. In cases where intervention was required, the help was generally related to literature referral. It was also the general conclusions of the teaching group that the increased focus on problem solving did not affect the technical conductance of experiments. It was, therefore, the general impression that the revised format for student guidance in the laboratory was successfully applied.

Observations done during the course

Based on the experiences from the past five years of lecturing this course, some changes in student behavior were evident. The following section is based on own subjective observations but all observations has been discussed with the teaching group and general consensus was achieved in relation to the following statements.

> *"The students were calm".*
> It was the general expectation from the teaching group that the very open format would confuse and frustrate some students. Eventually, this could mean that students would feel discouraged or stressed by not knowing which expectations to meet. This was, however, not the case. All students embraced the challenge in a calm and orderly fashion and they conceived and executed the experiments with high dedication.
> *"The students used the experiences from former experiments without any teacher encouragement".*
> Without any teacher involvement students immediately linked the different exercises and transferred the experiences obtained in one experiment to the planning of the next.
> *"It was the general opinion from the teacher group that the students were better prepared this year compared to last year".*
> The students seemed well-prepared and had read the sparse information in the lab manual and most had prepared individual notes and calculation for the experiments to be undertaken.

> *"Students struggle to relate obtained results to real life settings and sometimes lose faith in the validity of their results, their own capabilities and/or the overall aim".*
> Even though we as instructors take great effort in stressing that this course is based on methods as applied in the pharmaceutical industry we would still get asked: "How do they do this in the industry" and when we reply "This way" we were in part met with disbelief. Furthermore, students did not fully comprehend that problem-solving skills should be learned during this course, so a general reply to the student statement: "But it's impossible to do it like this" quickly became: "then come up with a solution... or go tell the boss that he will have to throw away a product worth 20 million because you do not know how to analyze it..." However, eventually the students understood the format and the statement "If you can't do it the right way, do it another way..." became accepted as indicative that not all solutions are described in literature and that it is better to try and to fail than not to try. Hereafter, the quest for results was well undertaken by all students.

Furthermore, it was the general perception of the teaching group that we maintained a non-threatening environment in which the students thrived even though student-teacher interactions were sometimes retained at a minimum.

Student evaluation of the course structure as applied in the laboratory

At the end of the laboratory part of the course, students were asked to give an oral evaluation of the course based on their experiences in the laboratory.

In regard to the planning and execution of the practical part of the course, the comments from the students reflected a general appreciation of the format with important suggestions for alterations.

The students believed that there was ample time for the experiments and appreciated that they could plan their own time in the lab. This included that they could fill in the gaps between experimentation or while waiting for results with planning of the next experiment or literature scrutiny.
Student comment: "It's good that we have so much time for the exercises, otherwise it would be very frustrating not knowing what to do in the exercises"
Student comment: "We can spend the time reasonably while we are here"
Students also liked that they could repeat some of the exercises, if necessary.

Student comment: "It's good with the repetition of an experiment, the purpose became clearer."

All students agreed that it was an advantage that we apply industrial relevant experiments in the course and would prefer an increased focus on the final QC report.

The students argued that they would have liked some more theory to begin with before entering the laboratory. However, when asked, most agreed that it is more valuable to have a "hands on" experience with the assay before applying theoretical considerations. A feasible alternative was suggested by one of the students that waiting time occasionally associated with an exercise could, to a greater extent, be used constructively for student-teacher interactions regarding the related theory. With regard to non-exercise related theory, it has, however, always been the intention of the teaching group to begin the course with a general theoretical session to get students on the "right track" from the beginning. But for logistical reasons, we had to start with the laboratory exercises from day one of the course.

Another related request of the students was that more literature should be made available beforehand for preparations. I believe that this request could be interpreted in several ways. An obvious (and perhaps convenient) interpretation would be that the students are highly dedicated and want to learn more. Another less flattering interpretation could be that the students are uncomfortable with the problem-based approach and that they prefer some guidance in their literature search confining the possibilities to formulate their own project. However, with due respect to the fact that the students are presented to a new area of expertise with a different set of tools than they are use to, I chose to interpret this request as reasonable wish to be guided in the right direction before major considerations regarding assay designs are discussed amongst group members.

Contradictory to our general beliefs, the students did not perceive the limited student-teacher interactions as positive. We were under the impression that the students liked our distant approach so they would have a chance to discuss general issues amongst themselves without teacher involvement. However, according to student statements they felt that we as teachers tended to situate ourselves in a group away from the students, making us more unapproachable for questions and discussions. This observation is regarded as very important since it represents a problem without any obvious solution. We can easily recognize that we did situate ourselves away from the students but for the sole reason of letting the students work independently. But if the students in any way feel that we are unapproachable in these situations, we may be facing a problem with the format. It is the obvious suggestion that we in the future are in closer proximity to the students and try to keep teacher-teacher discussions to a minimum. However, this must not affect the independence and lively discussions amongst students.

Implementation of the new course structure in the theoretical part

The two weeks of the course spent outside the lab was divided between:

- Group work (completion of reports, preparation of presentations, and general discussions).
- Discussions with opponents (time was reserved for discussion of findings and how challenges were overcome by the different groups, we hoped that this would provide a forum for knowledge transfer).
- Lectures by teachers (a theoretical walk-through of the different techniques used during the course).
- Presentation from QC professionals (from Novo Nordisk and CMC biological) mainly centered around how the QC tests we used in the laboratory are conducted on a routine basis and how the results affects their daily work.
- Student presentations (QC report findings, theory and results from their self designed project and presentation of original literature.

In general, the teaching group had little involvement in the group work and discussions with opponent groups and thus, did not get a good feeling as to how the time was spent. The lectures seemed to interest the students and basis for good discussions was formed. Likewise the presentation from the QC professionals seemed to interest the students and the consensus between the daily work of a QC professional and the tests that we had worked with, further validated the relevance of the course. We also found the student presentation to be of a fairly high quality and they were, in general, well-structured and comprehensive. The subsequent discussions were, therefore, fruitful and interesting. We felt that the students had spent the majority of their time on findings from the QC report and this was interpreted as sincere student interest in the project. One downside to this was, however, that it became somewhat one-sided to hear the results of eight fairly similar projects which also seemed to bother the students.

The final course evaluation was done by a student evaluation form as shown below where the results are included.

Student evaluation form for Quality Control of Medicines –microbiological and immunological approaches, Jan 2011

Dear Student!
Your input is very important in order for us to prioritize which educational aspects of our courses should be improved. Therefore, we kindly ask you to fill in this form. Your responses will be anonymous. The overall results will be used by the lecturers and the Teaching Committee of this institute to improve the quality of our courses – and we thus appreciate your sincere and constructive feedback.
Yours sincerely,
Erik Wind Hansen, Lise Moesby and Michael Timm
Name of course: Quality Control of Medicines

Course Objectives: To give students the opportunity to learn, evaluate and conduct Quality Control of medicines using a microbiological and immunological approach. The methods described in Ph.Eur. and other regulatory authorities are addressed.

Please indicate with an 'X' the answer that best represents your opinion (only one 'X' per row)	1 Strongly agree	2 Agree	3 Neutral	4 Disagree	5 Strongly disagree	Don't know
I experienced a good correspondence between the teaching and the course objectives (as indicated above)	2	13	2			
I think that the practical execution of the course was successful (facilities, equipment, information dissemination etc.)	2	10	3	1		1
I experience a good coherence between the various course elements (lectures, practical work, etc.)		10	6	1		
I experience the course as relevant to my personal educational objectives	7	8	1			1
In cases where I needed feedback on my work (presentations, assignments, papers, reports) I was able to adequately get such feedback from the teachers	7	8	1			1
For me, the teaching material is adequate for this course.	1	5	6	4	1	
I liked that the course was relevant for quality control in the industrial setting	10	7				
I preferred the problem orientated approach to the subject over the traditional laboratory course approach	2	10	5			

Compared to my background knowledge I experience that the academic level of the course is:					
1 Far too low	2 Low	3 (16) Adequate	4 (1) High	5 Far too high	Don't know

I experience the work load of the course as:					
1 Much too low	2 (4)* Somewhat low	3 (10) Adequate	4 (6)* Somewhat high	5 Much too high	Don't know

*some responders had marked both 2 and 4 as an option indicating that the work load was somewhat low in the fall and somewhat high after the Christmas break

7.5 ECTS-points: In this course, for me the average work load per week was (including classes, preparation, written assignments etc.):					
1 Under 10 hours	2 10-15 hours (3)	3 15-20 hours (12)	4 20-25 hours (4)	5 25-30 hours	6 Over 30 hours (1)

List three things that should be kept in the course next year
I have listed the statements by the students in a slightly categorized and reduced form and listed the number of students having supported the statement: The QC report (6) Oral presentations by the students (6) That we centered the course around test with an industrial applicability (5) That the same products were tested repeatedly by various tests (5) Exercise D (the student designed project) (5) The high number of teachers associated to the course (4). Use of scientific papers (3) The order of which we conducted the lab/seminars (2) Lectures by the teachers (2) Lectures by QC professionals (2) The Lab manual (2) Working with "real life" problems (1) The general good vibe in the laboratorium (1)

List three things that should be changed in the course next year and indicate how!
I have listed the statements by the students in a slightly categorized and reduced form and listed the number of students having supported the statement: Distribution of the work load; before/after the Christmas break (8) More theory (primarily in the context of general immunology and introduction to excercises (8) Clear curriculum definition from the start (5) Use lab pauses more efficiently (4) More communication via absalon (4) Communication between teachers and students regarding the preparation of the QC report (3) More information regarding the exam (3) Not necessary to hear all QC reports presented (2) More mixing of theory and experiments (2) Too much time for group work (2) Student abstracts from the scientific papers should be edited/approved by teachers before distribution (1) More structure (1) Teachers should have encouraged more to general discussions (1)

Analysis of student evaluation form

In general, the evaluation form is fairly consistent with the observations done by the teachers and the comments made by the students in the oral evaluation of the laboratory part.

We deduce from question 1-5 that the students, in general (with only a few exceptions), find that the course is well structured with good correspondence between course elements, objectives and relevancy. However, the questions regarding the adequacy of the course material truly divides the students. Many feel that they were to ill-prepared for the different tasks they were facing and would like to consult a text book or lab manual. Since we are experimenting with the minimally guided approach we would anticipate that some students would feel that the course material is insufficient since the idea is that they themselves should address the original literature or turn to the pharmacopoeias or similar regulatory guidelines. It is obvious that the background knowledge of the subject is too limited for them to know where to turn for relevant literature. We must, therefore, find a way to get students on the right track from the beginning so that they do not feel that they are wasting precious time chasing answers where none can be found.

Questions 7 and 8 are interpreted as a general approval of the course content and relevancy. We also consider this a validation of the problem based approach that we have tried to implement. It seems like the academic level has been appropriate as well as the workload. However, it seems that a better distribution of the load before and after the Christmas break should be implemented. The time spent on the course is slightly at the low end suggesting that we could increase our expectations of student preparation and perhaps introduce some immunology literature as “self study” or as preparation for the individual experiments. This would also in part be a response to the students who state that they would like more theory and like to spend the lab pauses more efficiently. Another obvious request from the student is to increase communication. I believe that this in part relates to the inexperience from us as teachers in using the minimally guided approach. In our eagerness to make the students work independently and without too many inputs from our side, we may have overlooked the need for communication in respect to other aspects such as; general information, technical questions and curriculum or exam information. A more structured approach to the communication is therefore desired.

Conclusion

All in all, we conclude that the students, in general, liked the new format and explicitly (in the evaluation form) showed their appreciation of the new core aspect that we have build the new course around, namely:

- The QC report
- That we centred the course around tests with an industrial applicability
- That the same products were tested repeatedly by various tests as one project and
- The lectures by QC professionals.

Moreover, the majority of students recognized the PBL approach to the course and appreciated that they had ample time to test and re-test the same products during the course. Most importantly, the students appreciate the oral presentations and subsequent debate regarding results and result evaluation and actually suggested that this should include opponent group evaluation of the QC report.

We also feel that we have met the majority of our success criteria in that: The overall design of the course allowed industrial and research based experiments to be conducted along with theoretical considerations, self-reflection and independent study.

The students felt that they had a problem-based approach to the questions raised in the course material, but it seems that they did not find that the guidance is adequate.

The students displayed in-depth topic understanding, read and understood the scientific literature presented, and in part displayed a critical approach to own results. Students have also suggested relevant improvements.

For the teaching group, there was a general consensus that the new format supersedes the old and that we all like the problem-based approach using analysis of two pharmaceuticals in multiple test systems. Also, the inclusion of QC professionals seems to inspire the students and we as teachers appreciate the validity it gives our topic choice. We also felt that the students learned from their mistakes and it seems that the final QC report with the "go/no-go" decision regarding the release of pharmaceuticals encouraged the students to profoundly reflect on their obtained results.

We feel that student acceptance of and consent to the format chosen was very limited and that they were frustrated over the minimally guided approach. In some cases, they felt distanced from the teachers even though teachers were heavily represented in the laboratory and in the classroom sessions. I do not think that this shows a discontent with the format, in general, but that it reflects a frustration among students who simply do not know what is expected of them. In my opinion, this is a clear example of a misinterpreted (or lack of) didactical contract between students and teachers. We should from day one have informed the students how we expected that the minimally guided approach should be used in the lab, how our teacher involvement should be in the student projects and finally, how this approach affects the exam. Moreover, it should be underlined that our lack of "teaching" should be compensated in part by an independent literature search by the students (at any given opportunity) and a subsequent discussion of the data collected.

If the increased focus on the didactical contract will make more students accept the format of our project based, minimally guided approach remains to be seen. But it is the intention of the teaching group to keep the herein described course format. The changes suggested by the students will be implemented to further improve the student acceptance and, hopefully thereby, the willingness and ability to learn.

Global bibliography

Andersen, H. L. (2005). *Eksamensformer: Valg med konsekvenser*, Center for undervisningsudvikling, Århus Universitet.

Angelin, M. & Ramström, O. (2010). Where's Ester? A Game That Seeks the Structures Hiding Behind the Trivial Names, *J. Chem. Educ.* **87**(4): 406 – 440.

Biggs, J. B. (1996). Enhancing Teaching Through Constructive Alignment, *Higher Education* **32**(3): 347 – 364.

Biggs, J. B. & Collis, K. F. (1982). *Evaluating the Quality of Learning: The SOLO Taxonomy*, New York: Academic Press.

Biggs, J. & Tang, C. (2007). *Teaching for Quality Learning at University*, SRHE and Open University Press.

Black, P. & Wiliam, D. (1998). Assessment and classroom learning, *Assessment in Education: Principles, Policy & Practice* **5**(1): 7–74.

Bligh, D. A. (1972). What is the Use of Lectures?

Bruff, D. (2009). *Teaching with Classroom Response Systems: Creating Active Learning Enviroments*, San Francisco, CA: Jossey-Bass.

Bugeja, M. (Retrieved December 8 2010). Classroom Clickers and the Cost of Technology. The Chronicle of Higher Education.
URL: *http://chronicle.com/article/Classroom-Clickersthe/6009*

Butler, R. (1988). Enhancing and undermining intrinsic motivation: The effects of task-involving and ego-involving evaluation on interest and performance, *British Journal of Educational Psychology* **58**: 1–14.

Capps, K. (2008). Chemistry Taboo: An Active Learning Game for the General Chemistry Classroom, *J. Chem. Educ.* **85**(4): 518.

Chambers, R. G. (1988). *Applied Production Analysis. A Dual Approach*, Cambridge University Press, Cambridge.

Christiansen, F., Rump, C. & ller Madsen, L. M. (2009). Using teacher training courses as levers for faculty educational development, *in* A. Bisel & M. Garib (eds), *Proceedings of the Frontiers in Science Education Research*, Easter Mediterrranean University Press.

Christiansen, F. V. & Olsen, L. (2006). Analyse og design af didaktiske situationer – et farmaceutisk eksempel, *MONA* **3**(3): 7 – 23.

Crouch, C. H. & Mazur, E. (2001). Peer Instruction: Ten Years of Experience and Results, *American Journal of Physics* **69**: 970 – 977.

Davis, B. G. (n.d.).

Department of Mathematics, Cornell University, USA (2005). GoodQuestions at Cornell University. Retrieved 2011, from Department of Mathe-

matics, Cornell University's website.
URL: *http://www.math.cornell.edu/ GoodQuestions/index.html*

Dewey, J. (1995). Science as Subject-Matter and as Method, *Science and Education* **4**(4): 391–98.

Fagan, A. P., Crouch, C. H. & Mazur, E. (2002). Peer Instruction: Results from a Range of Classrooms, *Physics Teacher* **40**: 206–209.

Farma (2007). Nyudannede farmaceuters erhvervsstatus 2007.

Forsvarskommandoen (1989). *Undervisning i praksis*, Steen Lasse Møller Aps.

Gibbs, G. & Simpson, C. (2003). Does Your Assessment Support Your Students' Learning?, *Learning and Teaching in Higher Education* **1**: 3 – 31.

Gross, L. J. (2004). The Interface of Mathematics and Biology, *Cell Biology Education* **3**: 85 – 92.

Gunstone, R. & Champagne, A. (1990). *Promoting Conceptual Change in the Laboratory*, London: Croom Helm, pp. 159–182.

Hahn, K. E. & Polik, W. F. (2004). Factors Influencing Success in Physical Chemistry, *Journal of Chemical Education* **81**(4): 567.

Herrington, D. G. & Nakhleh, M. B. (2003). What Defines Effective Chemistry Laboratory Instruction? Teaching Assistant and Student Perspectives, *J. Chem. Educ.* **80**: 1197 – 1205.

Hofstein, A., Navon, O., Kipnis, M. & Mamlok-Naaman, R. (2005). Developing Students' Ability to Ask More and Better Questions Resulting from Inquiry-Type Chemistry Laboratories, *Journal of Research in Science Teaching* **42**: 791 – 806.

Johnsson, A. (2010). The Use of Transparency in the 'Interactive Examination' for Student Teachers, *Assessment in Education: Principles, Policy & Practice* **17**: 183 – 197.

Johnstone, A. H. & Al-Shuaili, A. (2001). Learning in the Laboratory; Some Thoughts from the Literature, *University Chemistry Education* **5**: 42 – 51.

Kagan, S. (1994). *Cooperative Learning*, San Clemente, Calif: Kagan Cooperative Learning.

Kirschner, P. A., Sweller, J. & Clark, R. E. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problembased, Experiential, and Inquiry-Based Teaching, *Educational Psychologist* **41**: 75 – 86.

Kvale, S. (1997). *Interview: En introduktion til det kvalitative forskningsinterview*, Copenhagen: Hans Reitzels Forlag.

Lasry, N. (2008). Clickers or Flashcards: Is There Really a Difference?, *The Physics Teacher* **46**: 242 – 244.

Leech, B. L. (2002). Asking Questions: Techniques for Semi-structured Interviews, *Political Science and Politics* **35**(4): 665 – 668.

Mazur, E. (1996). Are Science Lectures a Aelict of the Past, *Physics World* **Comment: Forum**: 13 – 16.

Mazur, E. (1997). *Peer Instruction: A User's Manual*, New Jersey: Prentice Hall.

Mazur, E. (2009). Farewell Lecture?, *Science* **323**: 50 – 51.

McCracken, G. (1988). The Long Interview, *SAGE University Paper Series on Qualitative Research Methods* **13**.

Meilgaard, M., Civille, G. V. & Carr, B. T. (2007). *Sensory Evaluation Techniques*, 4th edition edn, Boca Raton, Florida: CRC press.

Mertler, C. A. (2001). Designing Scoring Rubrics for Your Classroom, *Practical Assessment, Research & Evaluation* **7**(25).

Peer Instruction: From Harvard to Community College (n.d.).

Peirce, W. (2010). Designing Rubrics for Assessing Higher Order Thinking. A Workshop Presented at AFACCT Howard Community College, Columbia.
URL: *http://academic.pgcc.edu/~wpeirce/MCCCTR/Designingrubricsassessingthinking.html*

Rollnick, M., Zwane, S., Staskun, M. & Green, G. (2001). Improving Pre-Laboratory Preparation of First Year University Chemistry Students, *International Journal of Science Education* **23**: 1053 – 1071.

Schneider, M. (2007). Student-Activating Lectures in Almen Cellebiologi: 'Active Thinking Activities' as a Tool for Better Understanding of Basic Concepts.

Schulz, W. & McRobbie, C. (1994). A Constructivist Approach to Secondary School Science Experiments, *Research in Science Education* **24**(1): 295 – 303.

Sözbilir, M. J. (2004). What Makes Physical Chemistry Difficult? Perceptions of Turkish Chemistry Undergraduates and Lecturers, *J. Chem. Educ.* **81**: 573 – 578.

Tamir, P. (1989). Training Teachers to Teach Effectively in the Laboratory, *Science Education* **73**(1): 56 – 69.

Tsaparlis, G. & Gorezi, M. (2005). A Modification of a Conventional Expository Physical Chemistry Laboratory to Accommodate an Inquiry/Project-Based Component: Method and Students' Evaluation, *Canadian Journal of Science, Mathematics and Technology Education* **5**: 111 – 131.

Tyler, R. W. (1949). *Basic Principles of Curriculum and Instruction*, University of Chicago Press, Chicago.

Wiere, A. & Gängler, H. (2008). Hausaufgaben sind überflüsig, Technical University of Dresden, see http://tu-dresden.de/aktuelles/newsarchiv/2008/02/hausaufgaben/newsarticle_view.

Wingreen, N. & Botstein, D. (2006). Back to the Future: Education for Systems-Level Biologists, *Nature Reviews Molecular Cell Biology* **7**: 829 – 832.

Xella, S. (2009). Improving the Lecture Format.

Yamane, D. (2006). Concept Preparation Assignments: A Strategy for Creating Discussion-Based Courses, *Teaching Sociology* **34**: 236 – 248.

Yorke, M. (2003). Formative Assessment in Higher Education: Moves Towards Theory and the Enhancement of Pedagogic Practice, *Higher Education* **45**: 477 – 501.