2

Redesigning the course: “Dynamisk biokemi” for B.Sc. in Pharmacy

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Aim

The aim of this project is to redesign and optimize the course ”Dynamisk biokemi” for students taking a B.Sc. in Pharmacy so that the teaching and learning activities (TLAs) better support deeper learning, i.e. enforce understanding rather than memory.

Background

The course ”Dynamisk biokemi” is a mandatory course for students taking a B.Sc. in Pharmacy. The course is placed in the 3^{rd} semester and has a volume of 36 lectures and 14 tutorials (Fig. 2.1), equivalent to 7.5 ECTS (206 hours including 153 hours for preparation and a three hour exam). The intended learning objectives (ILOs) for the course are comprehensive and contain several aspects within biochemistry including cellular organization, replication, enzyme and receptor function and kinetics, as well as metabolism of glucose, amino acids and fatty acids. Since “Dynamisk biokemi” provides the fundamental basis for understanding physiological and pathological conditions at the cellular level as well as understanding possible targets for drug intervention, this subject is crucial for students taking a B.Sc. in Pharmacy. Accordingly, it is of great importance that the students obtain sufficient knowledge within the field of biochemistry to be able to follow the subsequent courses included in the study program for B.Sc. in Pharmacy.

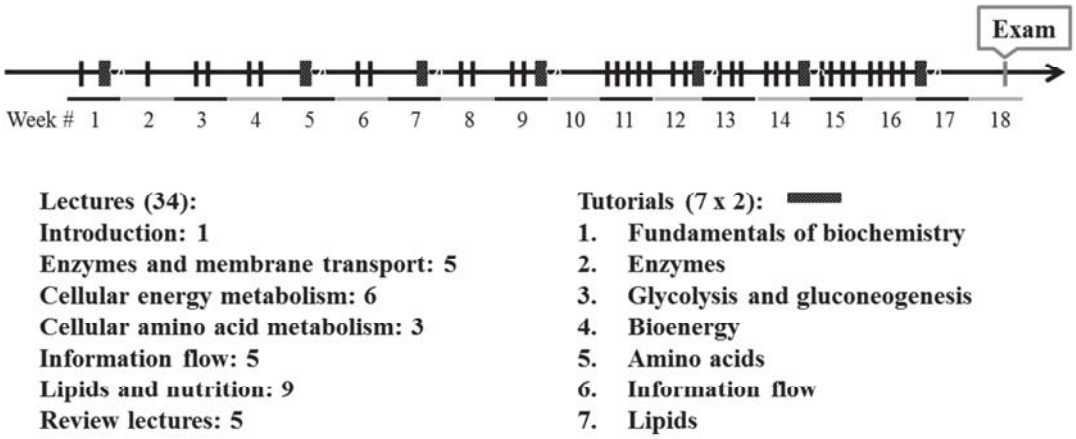

Fig. 2.1. Schematic overview of the current course design.

Currently, about 40% of the students fail this course and this proportion has been more or less stable for at least a decade although it increased slightly when laboratory exercises were removed (these were removed for economic reasons). The reason for this high proportion of students failing the course has been intensely speculated, the most likely explanation being that the students do not read the curriculum during the semester but begin to study only a couple of weeks before the exam. This may be a consequence of "Dynamisk biokemi" being placed simultaneously with other courses like "Farmaceutisk fysisk kemi" (12 ECTS), "Bioorganisk kemi" (6.5 ECTS), "Farmaceutisk mikrobiologi" (9 ECTS, divided into the third and fourth semesters, approximately 4 ECTS in third semester) and "Videnskabsteori" (3 ECTS), i.e. the workload on the third semester is high (above 30 ECTS). In addition, both "Farmaceutisk fysisk kemi" and "Farmaceutisk mikrobiologi" have laboratory exercises with reports, and approval of these is required in order for the student to sign up for the exams associated with these courses. Accordingly, it appears that students prioritize the courses that require approval of reports during the semester while "Dynamisk biokemi" is not prioritized until the exam is approaching. The exam consists of four parts which each account for 25% of the final score. One part comprises 21 multiple choice questions each with three possible answers while the other three parts consists of four questions each which do not necessarily contribute equally to the final grade. It is ensured that a broad spectrum within the curriculum is assessed by always having three different topics in the three question parts. Another issue which constitutes

a problem with regard to a large proportion of the students failing the course is that the students tend to rely on memory rather than understanding in their approach to learning (as described by Eric Mazur), as indicated by the following sentence repeatedly used by students: “there are so many things to remember". Although this statement is to some extent reasonable since the curriculum is comprehensive, the issue of relying on memory rather than understanding appears to be reflected in the final assessment in which a large proportion of the students are not capable of employing logic or reason when solving problems. Finally, the course design itself could be improved since it is not optimal to teach a practical subject exclusively by using theoretical methods, i.e. to teach a “wet” subject in “dry” surroundings.

Provided the theoretical nature of “Dynamisk biokemi” in its current form, several initiatives have been taken in order to make the students work during the semester and thereby encourage deeper learning (i.e. enforce understanding rather than memory). The use of “clickers” has for several years been an integrated part of the lectures and serves to continuously test the students within the topics that have just been explained. The test results are used by the teacher to evaluate the students’ understanding and determine whether to proceed with the next topic or keep focusing on the previous topic, i.e. the teaching is continuously adapted to the students’ needs. Moreover, the “clickers” results give the students some feedback on their understanding on a given topic. In the tutorials, the problems to be solved have been designed so that they are comparable to exam problems in order to secure constructive alignment in the course and to ensure that the students are familiar with the type of problems they are confronted with in the final assessment. Also, the tutorials are designed to encourage the students to present the answers to the problems in groups of two or three in order to obligate the students to read the textbook during the semester and actively participate in the tutorials. Finally, from September 2013, the students will have access to a virtual laboratory exercise on enzyme kinetics (provided by Labster, Copenhagen, Denmark). The initiatives that have been taken with regard to changing the teaching methods are in agreement with the theory of constructivism proposed by Shiiland (1999), particularly the part that “Learning requires mental activity”. However, since the concept of the tutorials requiring active student participation has not been incorporated into the course description (Fagbeskrivelsen), the implementation of this concept has only partially been successful. With that said, given the limitations of the current course design providing only theoretical teaching, several

initiatives have been taken. In order to further optimize the students' learning within biochemistry, a new course design is required which implements laboratory exercises and redefines the assessment form.

Strategy

One of the underlying problems leading to a high proportion of students failing "Dynamisk biokemi" appears to be the high workload on the 3rd semester for students studying for a B.Sc. in Pharmacy. However, this project will focus only on initiatives which can be implemented at the course level and not at the education level. In order to consider an improved teaching strategy, this project will focus on describing an ideal biochemistry course of 7.5 ECTS (i.e. a workload equivalent to approx. 210 hours) which is not changed from the current course design. The major changes within the revised course design are implementation of three laboratory exercises as well as changes in the assessment since group reports from laboratory exercises will be evaluated and the grade will contribute to the final assessment. In order to implement the laboratory exercises within the current volume of the course, i.e. 7.5 ECTS, it is necessary to cut the amount of lectures from 36 to 25 and the amount of tutorials from 14 to 10. This revised course design describing an improved teaching strategy will not be restricted by limitations in resources such as teaching capacity, cost of chemicals or access to equipment. Neither will a possible requirement for external examiners for evaluation of group assessments be taken into account.

The revised course design

In order to implement laboratory exercises, the amount of lectures and tutorials needs to be reduced so that the revised course in "Dynamisk biokemi" encompass 25 lectures, 10 tutorials, one virtual laboratory exercise (approx. 3 hours) and three laboratory exercises (4 hours each), exam (3 hours) and preparation (153 hours; Figure 2.2).

The ILOs of the course will be as follows (these are not significantly different from the current ILOs):
After having attended the course "Dynamisk biokemi", the students should be able to:

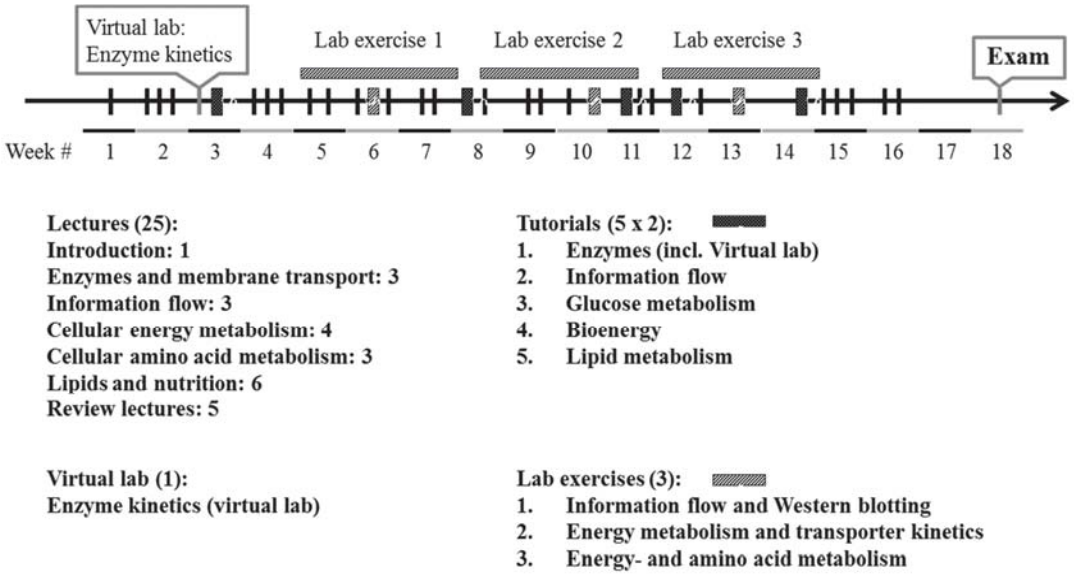

Fig. 2.2. Schematic overview of the revised course design.

1. Describe the cellular organization
2. Explain processes involved in replication and transcription
3. Classify enzyme function and -kinetics
4. Classify membrane transporter function and -kinetics
5. Describe receptor function and second messenger systems
6. Distinguish different metabolic pathways involved in the metabolism of glucose, amino acids and fatty acids
7. Describe the interaction between these different metabolic pathways
8. Describe the interconnection between energy- and amino acid metabolism.

Lectures

The concept of the lectures in the revised course design will not change significantly from the lectures in the current course design and will still be based on interactive and student activating teaching methods.

Tutorials

The tutorials in the revised course design will still include solving of problems that resemble the character of those included in the final exam. In the

tutorials the problems should be illustrative of the ILOs of the course in order to ensure alignment. Active participation of the students will be ensured by including in the course description (Fagbeskrivelsen) that active participation in the form of student presentations is a prerequisite for signing up for the exam. In the tutorials having topics related to those of the laboratory exercises, the problems should be illustrative of the ILOs of the laboratory exercises as well.

Virtual laboratory exercise

The virtual laboratory exercise has been designed so that it illustrates different forms of enzyme kinetics as well as allosteric modulation (activation and inhibition), competitive, non-competitive and uncompetitive inhibition. The students are to complete different tasks in a virtual laboratory with a number of realistic features. For instance when using a pipette, the student must change the tip when switching between different solutions otherwise they will be met by an error message. Also during the task, the students can look up different relevant topics and explanations by clicking boxes within the program. This virtual laboratory exercise will illustrate the major concept of enzyme kinetics and regulation of enzyme activity and test the students' ability to identify these. This virtual laboratory exercise demonstrates 1) Enzyme kinetics and 2) Different ways of modulating enzyme activity.

"Wet" laboratory exercises

In the revised course design, laboratory exercises will be implemented. The virtual laboratory exercise on enzyme kinetics which will be implemented on the "Dynamisk biokemi" course in the fall semester 2013 will be maintained. In addition, three "wet" laboratory exercises with the topics: 1) Information flow, 2) Energy metabolism and transporter kinetics, and 3) Energy- and amino acid metabolism will be implemented. The concept of these laboratory exercises will be that the students receive a manual containing ILOs, objectives, a list of materials and apparatus available for the exercise and in some cases additional literature. The students are to work together in groups of four, and the groups have to design their experiments themselves. They should turn in a protocol for the experiment including an aim, a rationale for the designed experiment to be conducted as well as a

time schedule for their experiment approximately one week before the laboratory exercise. The protocols and time schedules need to be approved prior to the day of the experiment in order for the students to have access to the laboratory facilities. After having conducted an experiment (or having received the data which may take a couple of days) each group has one week to make a short report (approx. 2-3 pages) including a short background, the aim, the design of the experiment, results and a short discussion of whether the results match their expectations. The reports generated after each of the three laboratory exercises will be graded and each report will contribute to the final grade (for details see assessment below).

Description of the laboratory exercises

All laboratory exercises involve the use of stable cell lines.

Laboratory exercise 1

For laboratory exercise 1, each group selects one enzyme that they want to inhibit the expression of (after having been given a number of options; all available siRNA inhibit the expression of enzymes involved in energy- and amino acid homeostasis), and subsequently use Western blotting to test that the expression of the enzyme is diminished. In order to understand the mechanism of action of siRNA (which should be described in the protocol as well as in the report) it is necessary that the students are able to explain the different steps in replication and transcription. At the point when making a choice of what enzyme to inhibit the expression of in this exercise, the students are not acquainted with the different metabolic pathways and the choice may be rather random. However, at this point this is not crucial and the fact that the students have heard about a number of enzymes essential for the major metabolic pathways - and have worked with one of them - is likely to increase their attention at later points in the course. This laboratory exercise demonstrates 1) Consequences at the protein level of manipulation of the cells’ information flow.

Laboratory exercise 2

In laboratory exercise 2, each group tests the functional consequences of siRNA knock down of the enzyme chosen in laboratory exercise 1. This is

tested by measuring the cellular capacity to perform sodium coupled co-transport which is an energy demanding process, i.e. transporter kinetics. In addition, the effects of inhibiting glycolysis, glycogen degradation, TCA cycle activity, the electron transport chain (i.e. inhibitors of energy production) or the Na^+/K^+-ATPase will be tested using a variety of pharmacological tools when using glucose as an energy substrate. In this exercise transporter capacity is tested employing radioactively labeled substrates for Na^+-coupled transport. The students should choose one inhibitor or a combination of inhibitors and test the effect on transporter kinetics. In order to complete this exercise and the associated report, the students need to be able to explain transporter kinetics, which is comparable to enzyme kinetics, and this interconnection should be illustrated in this laboratory exercise. Also, in order to plan and conduct experiments testing an energy demanding process in the presence of different inhibitors of energetic pathways, the students need to be able to explain and distinguish the different energy producing pathways involved in glucose metabolism and identify which metabolic pathway they have manipulated when knocking down the enzyme in laboratory exercise 1. This laboratory exercise demonstrates 1) Transporter kinetics and 2) Energy production from glucose metabolism.

Laboratory exercise 3

In laboratory exercise 3, each group tests the metabolic consequences of siRNA knock down of the enzyme chosen in laboratory exercise 1. The group chooses one ^{13}C labeled substrate (glucose, a fatty acid and an amino acid will be available) that they want to investigate the metabolism of when the expression of the enzyme chosen in laboratory exercise 1 is knocked down. The cell extract is subsequently analyzed using mass-spectrometry providing information about how the ^{13}C labeled carbon atoms of the substrate is incorporated into organic- and (other) amino acids. In order to determine which ^{13}C labeled substrate to employ in this exercise, the students need to be able to distinguish the different metabolic pathways and identify which metabolic pathway they have manipulated when knocking down the enzyme in laboratory exercise 1. This laboratory exercise demonstrates 1) The interaction between different metabolic pathways and 2) The interconnection between energy- and amino acid metabolism.

Assessment

The assessment strategy in the revised course design is based on the concept that the students are assessed continuously during the course. Each of the three reports elaborated by the groups following the laboratory exercises contributes to the final assessment by 10 points, i.e. 30% of the final grade results from practical group work. This has two major purposes: 1) the course becomes important to the students early in the semester and thereby increases the students’ motivation to take a deeper learning approach when studying the subject and 2) the students are evaluated early in the semester and thereby receives some feedback on their understanding of the subject at an early point. The remaining 70% of the points included in the final assessment are obtained from a three hour written exam as in the current course design. From January 2014, the exam will be digital and such platform used for assessment will enable the student to receive a grade for the 25% of the exam being based on multiple choice questions immediately after submitting their answer.

Conclusions

This project has defined an improved course design for the biochemistry course “Dynamisk biokemi” having a volume of 7.5 ECTS. The major changes involve:

1. Implementation of laboratory exercises
2. Implementation of a new assessment strategy

Perspective

When this project was initiated, the prospect of the course “Dynamisk biokemi” was that the course design needed a major revision in order to increase the fraction of students passing the course. We (the teachers at the course) applied for money to implement the virtual laboratory exercise and the money was granted. However, we sincerely wanted to implement “wet” laboratory exercises also, and this project was constructed to rethink the course design and propose three laboratory experiments. In this process, the “Farmaceut 2020” initiative was commenced and the B.Sc. in Pharmacy is redesigned at the educational level. Therefore, the course “Dynamisk

biokemi" will no longer exist as a separate course after January 2016, and it is unlikely that the course will be revised to the extent described in this project before January 2016. However, since the laboratory exercises described in this project entail essential topics for students taking a B.Sc. in Pharmacy, it is likely that they will be implemented in the revised educational design which is currently being developed.

All contributions to this volume can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/2013-6/

The bibliography can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/

kapitler/2013_vol6_bibliography.pdf/