6 LEQ – student evaluation of the learning environment

The LEQ was handed out at the time for the written examination. The questions were available in both Swedish and English. The LEQ form included 28 standard questions.

Questions and LEQ spider chart

Figure 1 summarizes the results for the 22 standard questions in the LEQ analysis. The LEQ also includes 4 open questions (23-26). The 22 standard questions were scored 1-7 according to:

7 = Yes, I strongly agree
4 = I neither agree nor disagree
1 = No, I strongly disagree.

The average was adjusted such that the "I neither agree nor disagree" statement corresponds to the zero line by subtracting 4 from the average. This gives the +3 line corresponding to "I strongly agree"; the zero line, "I neither disagree or agree"; and the –3 line, "I strongly disagree".

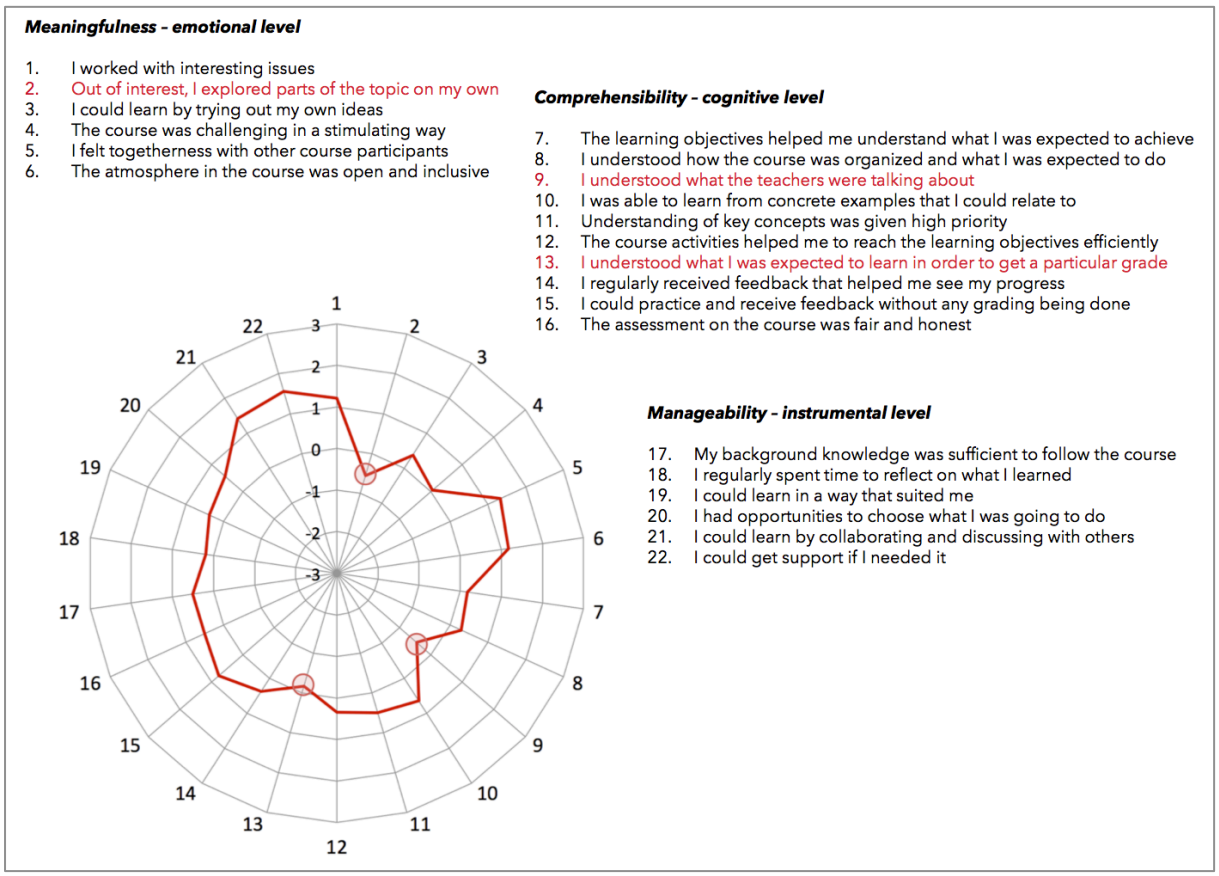

Figure 1. LEQ questions and spider diagram.

General statement

The zero line represents that a respondent does not have an opinion of the statement being either "good" or "bad" (I neither agree or disagree). While the overall scores are on in the positive range, albeit close to the zero line, there is considerable room for improvement. At the emotional level, it is clear that the students felt considerable frustration because some parts of the course were excessively challenging.

This is a new course that was given for the first time and included a number of new topics. Being the first course of the new master's programs, the teachers also had severe time constraints to optimally plan all aspects of the course before launching it.

While the students provided a substantial amount of both negative and positive criticism, they also provided a rich source of constructive suggestions for how to improve the course, which is tremendously valuable to me as course organizer. My overall conclusion is that the students feel that the course is important and valuable, and that it has a potential to become a very good course if proper revised.

The following five elements of the course will be analyzed in light of scores shown in the spider chart and the students' comments and suggestions for improvements. Page numbers in round brackets.

1. Course organization and contents

Background

The course is organized using three main elements: lectures, exercises and an independent project. Each element is described in more detail in their respective section.

Comments from the students

What was good?

- The course curriculum and the way it was taught.
- To get the chance to learn something new.
- Detailed lectures.
- The first lectures.
- When we begun to understand what we were actually doing
- Instructions between several main subjects, relevant today. Maybe this could be improved again with more applications.
- Interesting with new concepts.
- Interesting subject, some things were really new things that was interesting to learn.
- The understanding of how to validate the PDB structure.
- The labs, software wasn't bound to school systems even though it was sophisticated and specialized.
- The best with the course were the exercises, and studysheet.
- The project, but it should have been bigger and more in depth.
- The project, difficult to get a grip on in the beginning, but instructive.
- Fun to choose a project on your own, great to have supervison !
- The project even if it was hard to get started .
- The application, concrete, by the project.
- Especially the project was really helpful for learning.
- The new contents (modelling, mechanical statistics…)

- The exercises and the project was the best aspect because it helped me to work regularly and to apply knowledge and understand better the courses.
- The project, but it should have been bigger and more in depth.
- I think the subject was interesting.
- Supercool subject.
- I enjoyed the course.

What was not good, what would you suggest to improve?

- The course felt spread out on too many fields making it hard to go in depth on any of the area of the course. It would be nice if the math parts, especially the part with statistical mechanics, could be more integrated with exercises where we use the formulas.
- To be clear about the course instructions, for ex. feedback on the project which feels a bit unclear
- The course is much too broad.
- Some parts of the course need to be more clear. Communication with some teachers was sometimes difficult.
- Less teachers since they were of varying quality.
- The course is somehwat all over the place with pretty separate topics discussed only briefly.
- Overall the course had some good "moments" but most of the time we sat and just tried to learn a new program. Very sloppy and confusing course.
- I understand the idea with having lecturers who are experts on their topics but unfortunately it didn't work out. The level of the lectures were too high.
- The topics themselves were fascinating (HIV/drug design), but how we learnt about it was not so fascinating.
- Very unstructured course. The concept with different lecturer all the time made the course scattered. Very unclear what was expected in the project.
- Lectures and exercises didn't feel completely thought-out.
- The course was challenging, not stimulating.
- The course was overall very confusing.
- The course was challenging in a way that you didn't know what you were suppose learn.

Summary scores, student comments and examiner's analysis

The LEQ questions relating to the course organization and contents are 1, 4 and 8:

1. I worked with interesting issues (score +1.21)
4. The course was challenging in a stimulating way (score +0.04)
8. I understood how the course was organized and what I was expected to do (score +0.29)

There is a consensus among the students that they appreciate the subject, but feel that the course topics are too scattered and poorly integrated. In fact, from the large body of constructive criticism it is clear that they welcome this course in the new master's program, and that they sincerely want to help us make the setup better.

The students acknowledge repeatedly that (most) exercises and especially the project helped them understand the theory and acquire important practical skills for the future. I am very happy to see that students with biotech background as well as those with a different background, for instance mathematics, can follow and appreciate the course. I think we are onto something good here.

The students praise the opportunity to learn completely new topics that were not covered during the bachelor, and to get extensive opportunity to apply this new knowledge practically. Although the course is dense with hands-on and applied tasks (thanks to the exercises and project) they seem to want even more practical real-life applicability.

One thing that strikes me is that many students perceive the course as a methodology course, which is not a problem *per se*, but indicates that we can do better explaining the overarching course goals, i.e. to understand how structure of biomolecules link to their function, and how we can study this with different techniques.

Several students point out that having several teachers with varying level of pedagogical and language skills is a problem. They also acknowledge that the course topics and how they are taught are very challenging.

Planned activities to improve the course organization and content

1. To more clearly emphasize the overall goals, which are to understand how structure of biomolecules link to their function, and how structure can be studied experimentally and theoretically using different techniques. Since the students value the methodology and practical skills offered in this course, the overall goal must be emphasized, but not at the expense of less practical training.
2. To strengthen the practical aspect of the course while also strengthening the structure-function focus. This will be discussed in more detail below, but one likely action is to cut back on some practical parts to give more time for consolidation of the remaining exercises, and for the project. Some of the scheduled lecture time can also be cut back in favor of strengthening the foundations of the methodologies.
3. A number of measures will be taken to make the knowledge more accessible, most importantly by supporting the teachers in the team in adapting their teaching style from a pedagogical perspective.

2. Lectures

Background

A total of 13 lectures are given in the course distributed between five teachers who are well conversant with their respective subject, and with different amount of experience of teaching in second-cycle courses. The topics covered are listed below. Many of these topics have not been covered previously during their education and are new to the students. According to the students, topic 3, 4 and 5 had been sufficiently covered in previous courses, while the remaining topics were new and meaningful.

1. Basic concepts in structural biology
2. Folding and folding diseases
3. Structure of sugars, polysaccharides and lipids
4. Protein-DNA interactions and immune system proteins
5. Membrane transport and signal transduction
6. Energetics & Thermodynamics
7. Computational approach for modeling energetics
8. Statistical mechanics
9. Methodology for experimental structure determination
10. Validation of macromolecular 3-D models (experimental and theoretical)
11. Computational modeling of biomolecular structure I and II
12. Drug design from a structural perspective

Comments from the students

What was good? Did you understand what the teachers were talking about?

- Structured lectures (most of the time)
- Statistical mechanics, computational energetics were fun once you grasped the basics
- Statistical mechanics were explained very well
- Interesting topic, fun to learn about structure of biomolecules
- The lecture on structure and function was the only lecture that connected structure to function.

- To see the cool membrane protein structures and when I understood the concept of molecular dynamics and Monte Carlo.
- The first lectures were interesting but many varied.
- Depends on the subjects, and how it was explained.
- It varied between teachers. Some could express themselves well in a pedagogic way.

What would you suggest to improve? Did you understand what the teachers were talking about?

- Had been better to skip the parts on sugars, fats and immune defense etc. that we had on previous courses and to go deeper into X-ray crystallography or Monte Carlo.
- Less focus on things that have been part of previous courses like sugar structures, membranes, transporters, operons and so on. More lectures are needed at slower pace that deal with new central concepts like molecular dynamics, X-ray and Monte Carlo. These are tough topics and it is very difficult to understand what knowledge is important from the study sheet.
- Some lectures would need more in-depth, and someone really (pedagogical) to teach. Some lectures felt very basic and like repetition (would prefer to have spent less time on these and more on new subjects).
- Have a clearer focus of the lectures, some were too long for us to understand the focus.
- The number of lectures on some of the topics should be more.
- Bigger focus on molecular dynamics and more info on what it is about.
- More elaborate description and more context around concepts.
- To have 80 slides/lecture is too much.
- All lectures felt like they belonged to separate courses.
- Too many different teachers made the lectures hard to follow as well as slides.
- Too much information during one lecture.
- Focus on what is important in a clean general way, and take time to explain. It is nice to have additional info but it took time that we could have spent understanding key/basic concepts.
- Change the lecturing concept. Less slides. Fewer teachers to make it more consistent. A lot of details in the lectures, difficult to follow.
- Too many slides! Cut it down to half, better to have 40 slides where the protein is described a lot than 3 different ex.
- Depending on the subject, some lectures felt like repetition of the bachelor.
- L2, L3 and lecture about membrane proteins were a bit basic.
- Some lectures were too fast, I couldn't follow. With too many abbreviations that were sometimes never explained.
- The computational lectures must be more pedagogical! They were superhard to understand during the lecture. It will help with better headlines and no abbreviations without an explanation.
- Prepwork for lectures was announced a bit late.
- Depends on the lecturer, some were completely incomprehensible.
- The computational lectures were difficult to understand.
- It was sometimes difficult to understand what some teachers were talking about. Other teachers were very clear – good!
- It was very hard to understand what some teachers were talking about. This had to do with their language, not what they (the topic) were talking about!
- Mostly (I understood what the teachers were talking about), the equations regarding calculations of properties in MD and MC were not explained well.
- Difficult to understand some teachers.
- The computational lectures were a bit hard, but it's a difficult subject.

- Only one out of the four teachers that I could not understand at all.
- MD and MC lectures were hard to follow. Slower pace would be nice for these hard concepts.
- Maybe sometimes key concepts were hidden by too many details, additional info.
- MD and MC and forcefield lectures felt scattered.
- Further clarification, especially with respect to MD/MC would be appreciated.
- Less teachers next time. And a proper go through of the programs that we are using. Some teachers were exceptionally great like Lucie. Perhaps next time make all the lectures in the same form. Less slides with irrelevant text.
- It is better to have a course with 3 slides very clear, take time to explain, give lots of examples, than 70 slides and rushing on them.

Summary scores, student comments and examiner's analysis

The LEQ questions relating to the exercises are 9, and11:

9. I understood what the teachers were talking about (score -0.46)
11. Understanding of key concepts was given high priority (score +0.5)

It is very clear that some lectures were well received and some not, and in the latter case this was due to a combination of the topic being challenging and shortcomings related to the lecturing style, as well as a general lack of prerequisite knowledge of the students. Many students also felt that many lectures were too cramped with information. The students perceived some of the lectures too basic, and redundant with earlier courses in the bachelor. Furthermore, they felt that the course was scattered on disparate topics. All topics covered are intrinsic to structural biology in its broader definition. I think the student perceived the course topics as scattered because there was many new topics introduced, and too little effort put into describing how they relate to the bigger picture structural biology picture. The focus on the underlying theory of the new topics, i.e. molecular dynamics (MD), Monte Carlo (MC) and statistical mechanics, made the student feel diverged from the focus of the course.

Planned activities to improve the lectures (content and lecturing style)

1. To strengthen the focus on key concepts, all teachers will be asked to, at the end of each lecture, summarize the relevant learning outcomes from that lecture and to couple them to study-sheet instructions. I also want the teachers to explain clearly how the lecture outcomes couple to the broader learning objectives of the course and to the grading criteria. The same should be done for the exercises and project.
2. Furthermore, the teachers will be asked to displace the lecture focus from memorizing information, especially equations, and instead focus on conceptual understanding of the underlying theory. This is particularly important for the theory of MD and MC. The MD and MC parts also need to be simplified to meet the knowledge level of the students.
3. All teachers will also be recommended to revise their lectures to include less, but more conceptually informative slides.
4. All preparatory reading material associated with the lectures should be uploaded in the course Canvas at the start of the course.
5. It is recommended that all lectures more clearly couple structure to function, especially the more theoretically "heavy" computational lectures need to be better integrated in the course curriculum, and further calibrated against both the learning objectives of the course and the students' needs.
6. The lectures on topics where the basics has been covered in earlier courses at the bachelor degree should be revised to discuss these topics from a structure-function perspective at an advanced level. This relates mainly to the lectures on sugars, fatty acids, transcription, and membrane. There is a wealth of advanced structure-function information available for these topics that can be included at the expense of the basics, and also coupled to the methodological contents to the course.

3. Exercises

Background

There are six exercises, tutored by different teachers, and given twice per week to accommodate the large number of students and allow flexibility in the students' schedules. The computer labs are instructive, interactive computer-based exercises based on contemporary cutting edge research to provide practical skills and knowledge for increasing and deepen the perception and understanding of biomolecular structure-function relationships. The students acquire skills and tools to retrieve, use, understand, and validate structural biology information available in 3D structure databases. The students are also trained in using free computational tools to study the interaction of biomacromolecules with ligands and explain the driving force behind their association or binding and able to propose structure from sequence and to validate the data.

The exercises aim to apply knowledge from the lectures practically, and the intention is therefore that they should focus on key concepts taught in the lectures, but from the applied perspective. The exercises provide practical knowledge through extensive computer-aided interactive work and computational calculations that support deep learning and give an enhanced perception of biomolecular 3D structures, and how the structures relate to function.

1. Basic concepts in structural biology
2. Energetics
3. Map analysis and validation (experimental and theoretical models)
4. Drug design
5. Homology modeling
6. Molecular dynamics simulations

Comments from the students

What was good?

- The exercises were stimulating.
- Good exercises.
- I learnt a lot, and most of the computer exercises were good.
- 3D – cool!
- Using different softwares.
- The exercises were rewarding and fun.
- I liked the exercises, however they were a bit big for the time allocated.
- The exercises were good for understanding.
- The thought about the laboratory course was a nice aspect.
- We have learnt by hand how to use and analyze in various software.
- The understanding of how to validate the PDB structure.
- The labs, software wasn't bound to school systems even though it was sophisticated and specialized.

What was not good, what would you suggest to improve?

- Exercises, instructions.
- Computer modeling exercises because we didn't know the basis for programming.
- Give more background about the softwares before practical exercises.
- The work load was too heavy for some exercises.
- The exercises were completely based on computer knowledge and the time spent for these. You only focused on getting them over with and were exhausted after each exercise. Still it felt like I didn't learn anything.

Shorten the exercises and make them less computer-based, and if not, you need to have introductory sessions for all software before.

- Not as tight between exercises – another schedule.
- Instructions for computer exercises could be clearer and also more explanatory. Explanations of why we do steps and "callbacks" too equations or terms from lectures would be good in them to promote learning rather than just doing something.
- More exercises and application cases to get more familiar with what is expected (in real life and for the exam): strategy/analysis.
- It needs to be a bit clearer (the laboratory course).
- Improve the labs! It should not take 3.5 hours of trying to figure out what to do and what it means and 5 hrs of learning something useful.
- Design the exercises better so that there is time to reflect and not just focus on trying to interpret/understand the instructions.
- I had a hard time understand computational lectures.
- Labs went too fast, needed much more time to understand on my own even if prepared.
- Maybe it would be better with some exercises in the form of "corrected cases" for instance.
- The challenges in this course were frustrating, not stimulating. ex. 4 hours in a computer lab to understand how to use the software or programming and then learning something useful in the last 20 min.
- The labs took up time that could have been used to study for the course. They were not very helpful.
- Some teachers didn't comment the exercises sent.
- Could have been quicker evaluated exercises.
- Some of the coding (MD) was too advanced! I didn't understand the purpose of why I coded as I did.
- Actually, crystallizing or performing cryoEM instead of solely doing computer simulations would have given a better understanding. Also the Python lab: none of us had coding experience and the codes were incorrect mostly and I do not feel like I learnt anything. It was all copy paste.

Summary scores, student comments and examiner's analysis

The LEQ questions relating to the exercises are mainly 10, 11, 12, 14, and 15:

10. I was able to learn from concrete examples that I could relate to (score -0.65)
11. Understanding of key concepts were given high priority (score +0.50)
12. The course activities helped me reach the learning objectives efficiently (score +0.34)
14. I regularly received feedback that helped me see my progress (score +0.37)
15. I could practice and receive feedback without any grading being done (score +0.76)

Some of the exercises caused excessive frustration among the students. The main reason appears to be that several new softwares were used that were not sufficiently described beforehand. This was unfortunate and resulted in many students having to spend an unreasonable amount of time and effort before even being able to start with the task at issue. This is unacceptable since the chance to consolidate key concepts practically is limited by unnecessary technical problems.

Some students complained about not getting feedback on their lab reports, or getting feedback too late. This is unfortunate since the exercises are the best opportunity for us teachers to provide feedback both in-class during the 4-hour exercise sessions and outside class when commenting on the lab reports.

Planned activities to improve the exercises

1. We will try to streamline the software requirements to include less different program.

2. I would also suggest to work on the same, or similar, biological/biotechnological problems using different methodological approaches. For instance, to focus on one state-of-the-art task (e.g. in-depth structure-function analysis of a membrane transporter with the aim to develop new drugs) during the exercises and present the students with different methodologies/techniques (MD; MC, ligand docking and X-ray) to target the challenge.
3. I can also see a possible advantage to cut back on the number of exercises from six to three (or four) to provide more time for introducing the softwares, to consolidate the application of the different programs on the question at issue, and to free computer time for the project (see section 4 below). For instance, the exercises on drug design and homology modeling can be shortened and combined.
4. Many students do not have sufficient programming skills, and it is therefore advisable that the computational exercises are revised to require a minimum of prerequisite programming knowledge.
5. I will emphasize to the teachers the importance of prompt feedback on lab reports.

4. Project

Background

The goals of the project are: to prepare the student for future academic studies or outside academia (industry etc.) by: (i) implementing and applying course knowledge in authentic situations; (ii) build deeper knowledge and skills regarding use of state-of-the-art tools to retrieve, analyze and validate biomolecular structures, and to perform relevant computations for specific purposes; and (iii) to practice communicating scientific information in written and oral form.

The student project runs over the entire duration of the course. At the start of the course, the students are presented with four project themes, each with assigned supervisor(s):

- Theme 1 Analysis and validation of experimental structures
- Theme 2 Molecular dynamics simulations
- Theme 3 Molecular docking and drug design
- Theme 4 Homology modeling

Each group of students decides which theme they want to work with and signs up with the responsible supervisor for that theme. The theme supervisor discusses different project topics with each project group, and the group decides on a project. Each project group has a unique project relating to either of the themes.

These four themes are also covered by the exercises where all students are offered the chance to acquire basic skills in the methodology of the aforementioned themes, but through the project, students with special interest in a particular theme topic has the change to go deeper and work in a more realistic setting. Thus, by adding the project, the student becomes prepared to apply these skills on real examples. Through the written report and the oral presentation, the students acquire skills in disseminating their knowledge and findings in writing and speech. These dissemination forms train different special and general skills ranging from analytical ability to presentation technique and pedagogical approach.

Comments from the students

What was good?

- Difficult to get a grip on in the beginning, but instructive.
- Fun to choose a project on your own, great to have supervison !
- The project (was the best part of the course) even if it was hard to get started
- The application, concrete.
- Especially the project was really helpful for learning
- Very good project! It increases understanding

- Project was very interesting and it is really a good thing that we are not only graded on things we learnt by heart but also practice, thanks!
- The project, but it should have been bigger and more in depth.
- Difficult to get a grip on in the beginning, but instructive.

What was not good, what would you suggest to improve?

- One thing that could be good is to have more scheduled hours where you get to work on the project. That would have made things a lot easier in the beginning.
- The project felt unnecessary and took time from completing the exercises.
- Have a lab or something for Maestro earlier in the course, it would make it easier to start with the project.
- I would have wanted to learn about how the other projects work since knowledge from all themes were on the exam.
- The project is a bit small in scope for a successful MD simulation.
- The project was started much too late. The intro exercise for our project was three weeks into the project. One should have a meeting with everyone who work one the same project and at least run through the software early/immediately.
- Info about project clearer, what programs to use and introduction by supervisor.
- Better organization of themes.
- Too little information about the projects. Took three weeks to understand what we were going to do.
- Improve the planning of the project so that some students don't need to work to the last minute because they were taught the concepts a few days before.
- Don't see how the project was relevant because we didn't get sufficient info.

Summary scores, student comments and examiner's analysis

The LEQ questions relating to the project are mainly 2, 3, 10, 11:

2. Out of interest, I explored parts of the topic on my own (score -0.55)
3. I could learn by trying out my own ideas (score +0.38)
10. I was able to learn from concrete examples that I could relate to (score -0.65)
11. Understanding of key concepts were given high priority (score +0.50)
20. I had opportunities to choose what I was going to do (score +0.56)

The students are overall very positive about the project, and appreciate that they get the opportunity to apply their new knowledge on real cases. The low score for question 2, and also question 3, can be rationalized by the students' feeling of being under great time constraint to struggle to master what they perceive as very challenging course curriculum. To explore topics on one's one is however a fundamental and integral part of the project since the student themselves select a theme and topic that they are interested in. This question is often misunderstood and perceived as meaning something else than it actually does, which is why it often score low (my experience also from the very positively received course BB2160).

Also question 10 scores surprisingly low considering the amount of time devoted to theoretical and practical examples given in the course (in lectures and exercises). I have a feeling that this is a combination of different definitions of what can be considered "concrete", but also because some of the exercises suffered from technical (software) problems that lessened the learning experience. Question 11 scores a little higher, but still much lower than what I would consider acceptable. The purpose of the extensive practical modules (exercises and project) is to highlight the key concepts brought up during the lectures, to consolidate at a deeper level the understanding of the concepts, and importantly, to offer practical skills to be able to apply the knowledge on real cases.

Planned activities to improve the project

1. To allow all students to try out all project themes, and to provide more time for the project, I would like to reduce the number of themes to three. The three themes should be covered by three exercises, and the rest of the time scheduled for exercises can be devoted to project work. A tentative setup would then be that the students study theory during the first part of the course and do the practical work during the latter part. An alternative is to leave out MD from the project themes and keep it as a fourth exercise, leaving two lab sessions for project studies. The reason for leaving out MD is because the computer time needed to simulate real-life cases (typically weeks to months using powerful computers) is not within the time scope of the course.
2. The project themes need to be better communicated with more information at the beginning of the course, before the students make their choice. One possibility would be to allocate time from one of the first lectures for theme presentation where each teacher/supervisor take 15-20 min to introduce the theme, and directly after the presentation puts up suggestions for project topics on the course Canvas, allowing the students to select a theme and topic already during the first week.
3. Another improvement would be that as soon as the groups have selected theme/topic (during the beginning of the first week), each supervisor should schedules a mentor appointment with each of their project groups, and also arrange to have the groups test run the softwares during the first exercise that week. In this way all project groups would have a chance to get their project start immediately and not have to wait for the exercise.
4. I will also recommend that the project feedback is returned immediately after the project presentation (the final examination of the project), and that all teachers write a half page with feedback on the positive aspects, and half a page with constructive suggestions on how to improve the report and presentation (meant as advice for the future and also for the upcoming exam).

5. Learning objectives and study support

Background

There are six learning objectives stated in the course plan, course Canvas, and course PM. The course uses grading criteria (see Appendix 4).

1. Describe, formulate, analyze and evaluate fundamental concepts in structural biology. Learning level (a).
2. Suggest, motivate and discuss strategies for solving problems related to the function and applications of biomolecules in biology and biotechnology from a structural perspective. Learning level (b).
3. Based on knowledge and concepts acquired in the course, be able to propose, discuss and evaluate the role of bimolecular structural biology to advance understanding of biological and biotechnological scientific problems. Learning level (c).
4. Use computer software tools and relevant databases to visualize, investigate, analyze, evaluate and validate biomolecular structure information, and to make relevant computations. Learning level (a,b,c).
5. Design, plan, execute and present in written and oral form an independent project focusing on biomolecular structure and function. Learning level (a,b,c).
6. Critically evaluate own and others chosen strategies for targeting scientific problems from a biomolecular structure perspective, including assessing published recent advances in the current subject area. Learning level (a,b,c).

Comments from the students

What was good?

- The complementary questions were good.
- I answered all learning outcomes in a word document, it became much easier to understand, otherwise the course would have felt very scattered.
- The lectures were very all over the place without many words (just figures), so thank good for the objectives.
- Thanks to the studysheet.

- It was good with a studysheet but difficult to interpret what some of it was and how to approach certain subjects.
- The study questions were gold!
- Email – good respondence
- For project and during labs, good presence of teachers.
- Very good teacher support!
- Teachers great about meeting/emails for answering questions!

What was not good, what would you suggest to improve?

- The study sheet questions.
- The required memorizable knowledge should be collected somewhere.
- Be clearer on what is part of each question in the study sheet.
- Objectives were only indications of what was "expected" but had no idea what the exam would expect me to perform.
- Some study questions were clear, but some were too vague (if a formula, graph or explanation was wanted for example).
- Some parts of the course were difficult to understand and therefore difficult to know what to learn.
- The study sheet questions.
- Some exercises we couldn't get the help needed

Summary scores, student comments and examiner's analysis

The LEQ questions relating to the learning objectives and study support are 7, 12, 14 and 15:

7. The learning objectives helped me understand what I was expected to achieve (score +0.18)
12. The course activities helped me reach the learning objectives efficiently (score +0.34)
14. I regularly received feedback that helped me see my progress (score +0.37)
15. I could practice and receive feedback without any grading being done (score +0.76)
22. I could get support if I needed it (score +1.56)

As teachers at KTH we are required to use learning outcomes. The theory behind the construction of learning outcomes, and how grading criteria are used against these objectives is far from intuitive, and is not common knowledge among students, or even among most teachers at KTH. Learning outcomes, advisably as few as possible, must be constructed so as to cover the key objectives for the entire course. It is therefore not surprising that the student feels that they are not helpful in guiding them when studying for the exam, since at that stage the students are rarely able to see the bigger picture of what they have learnt and achieved. It seems that most students expect the learning outcomes for a course to be synonymous to a study sheet where each concepts and practical element covered in the course is covered. This is also the reason why I compile a study sheet that more concretely explains what is required to fulfill the broader learning outcomes. However, in its present state, the study sheet only includes "concepts" and only for grade level E. The students are very positive regarding the study sheet, but some also acknowledge that it can be improved further. I fully agree.

Furthermore, the students acknowledge that the teachers are accessible, helpful and supportive when approached.

Planned activities to improve the learning objectives and study support

1. The study sheet will be updated such that all teachers are required to carefully review and ascertain that their study objectives adhere to their lectures, and vice versa.
2. As discussed in section 2 (improvement of lectures), I want a strengthened focus on key concepts, and that these are clearly and transparently connected to the broader learning outcomes for the course. One step

towards this is to ask all teachers to summarize the relevant learning objectives at the end of each lecture (and exercise), and to couple them to both the course objectives and to the study-sheet instructions.

3. It would also be an advantage to set aside some time during the first lecture to go through the learning outcomes and how the different elements of the course serve to fulfill the objectives. It can be emphasized how the exercises and project meet the learning outcomes 1-3, and how the different topics covered in the course relate to learning outcomes 1-6.

6. Examination and grading system

Background

The learning outcomes and the associated grading criteria are provided in Appendix 4. The course modules are examined by a written exam (grades A-E). The written exam is divided in three parts according to three learning levels (a-c):

a. Central concepts
b. Hypothesis and strategy
c. Evaluation and analysis

Exercises are examined through mandatory attendance and passed exercise reports graded P/F. The project is graded on a written project report and an oral presentation in the form of a seminar and graded P/F. The course uses grading criteria for grade A, C and E. All information is easily accessible in the course Canvas. The course responsible has also informed the students *via* email of how the grading system works.

Comments from the students

What was good?

- Feedback for exercises were very useful and it feels better than a raw grade with no comments.
- Mostly good, but MD/MC was crammed with things that were unclear whether they had to be memorized or not, like formulas.
- The exam was reasonable (the info from lectures made it appear unreasonable)

What was not good, what would you suggest to improve?

- Change to a crediting system with point scoring.
- The E-level questions are more C-level I would say.
- Access to a more representative example exam. Clearer grading criteria.
- I think the exam had too high requirements for E. Difficult to know a little about many things.
- Example test not at all relevant with the course.
- I don't think the examination represents the learning outcomes.
- Maybe more exercises for the analysis/strategy parts (in the exam).
- The grading system makes it more difficult.
- The grading is very unclear.
- Change to a crediting system with point scoring.
- The E-level questions are more C-level I would say.
- Maybe more exercises for the analysis/strategy parts (in the exam).
- An exam where you need to pass all questions is not fair.
- Difficult to know what to learn to get E, It felt like the exam was very specific in some questions like Q8 and Q6 – not very general. Difficult to learn all formulas.

- Test exam was not relevant at all, in previous courses that were new the teacher have made an exam that actually was like the exam we were going to have. Don't see the point using last tears exam for a new course.

Summary scores, student comments and examiner's analysis

The LEQ questions relating to the grading system and examination are 13 and 16:

13. I understood what I was expected to learn in order to get a particular grade (score –0.17)
16. The assessment on the course was fair and honest (score +0.50)

The use of grading criteria coupled to learning outcomes did not make the students feel more comfortable about what they were expected to learn. I expected this based on my previous experience with this grading system in the previous course BB2160. The system requires a very thorough introduction, and sufficiently clear examples of answers meeting different grading criteria. Since BB2165 is a new course, we were not able to offer an example exam with student answers with different grades. I have done this in the past for BB2160, and since the general setup and some topics are to some respects similar for BB2165, an example exam from Bb2160 was posted in Canvas – including a disclaimer that the questions in the exam were not representative for BB2165.

A big "misconception" among the students is the way they interpret the grading of the written exam. When, for example, stating that "all grad E questions and most of the grade C questions must be correctly answered to achieve grade D", they interpret this literally, and not with reference to the grading criteria. This is reflected in some of the students' comments above. I was aware of this from my experience from BB2160 and therefore sent separate information (by email) to the students where I explained how the system is used when marking the exam.

It is my opinion, by looking at the students' results from the written examination, that their worries based on this misconception was unjustified. The overall performance is good. The degree of performance and examination were 87% and 74%, respectively, and 63% of the students that passed the written exam received grades in the higher regime (A, B, C).

KTH has a reinforced the requirement that all courses should use grading criteria, and therefore, this is not within the course responsible's is in a position to oppose. I am conversant with grading criteria, and have also taken the course LH216V (Develop the learning by using grading criteria), but I still have a deep understanding of the students' point of view. The theory behind grading criteria is non-intuitive and it is my opinion that their implementation and use require that teachers and also students have formal knowledge of this theory. The course LH216V is excellent, and if this grading system is to be used at KTH, it should be mandatory for all teachers to take the course. However, it is not within possible reach to expect that the teachers will have the possibility to set aside sufficient time in their courses for educating the students on this theory.

Planned activities to improve the examination and grading system

1. The most constructive way to alleviate the perceived frustration among the students will be to offer clear examples from the students' own answers that fulfill the different criteria, and next year we will be able to do that.
2. Besides example exams, I will provide more information to the students early in the course (in class, through email, and on the course Canvas), and also inform the teacher team to design example questions with answers to be posted on the course Canvas.
3. Coming exams will have a stronger focus on the higher learning levels, "hypothesis and strategy" and "evaluation and analysis", and less on memorizing concepts. It should for instance not be required to memorize extensive amounts of equations.
4. From experience with my previous practice in BB2160, I want the teachers in the team to more clearly couple the exam questions to the exercises and project, since these modules are meant to train the higher levels of knowledge.
5. Each teacher should be able to motivate how each study-sheet objective relates to the learning outcomes of the course and the grading criteria.

7. Social aspect of the environment

Background

The students have different backgrounds. Most students are from the Biotechnology program, but a significant number are international exchange students. The gender balance was relatively even with a slight excess of women. There was also considerable diversity with respect to ethnicity. In the course, the students are encouraged to work together, discuss and reflect. During the exercises and project they work in groups of 2-3 students. They also write all reports together.

Comments from the students

What was good?

- I like the fact to work in groups for the exercises.
- Good for exchange students: project in small groups.
- Project is a nice way to gather students and help each other.
- Good and easy lecturers to talk to.
- Thanks for project and exercises.
- Labs and project!

What was not good, what would you suggest to improve?

- Mostly own work. My group member in the project didn't do anything at all. Also goes for the computer exercises.
- More connection within the students for better learning.

Summary scores, student comments and examiner's analysis

The LEQ questions relating to the social environment are 5, 6 and 21:

5. I felt togetherness with other people in the course (score +1.32)
6. The atmosphere in the course was open and inclusive (score +1.17)
21. I could learn my collaborating with others (score +1.42)

All questions relating to the social environment score on the positive side in the score range. This shows that the mix of students and the course setup with teamwork are important factors to create an emotionally positive learning environment. As discussed in section 5 above, the students are also content with how they can interact with the teachers, which is also an important factor to create a social environment that supports learning.

For one group, the teamwork broke down for unknown reason. The reason was that one of the students id all the work. This is unfortunate, but rare. During my 12 years that I have been giving the course BB2160, it has happened only once.

Planned activities to improve the examination and grading system

1. I will inform the students that if the teamwork does not work out, they need to immediately contact me or any of the other teachers.

8. The students advice for next year's students

- Prepare after every lecture or exercise. Study.
- Stay active.
- Study and follow from the beginning.

- Start early with study sheet
- Ask a lot!
- Go through the lectures. Look through the study sheet early.
- To really take in and use the exercises.
- Keep attentive and try to get an idea of the basics early.
- Ask anything you don't know because it is very important to understand everything.
- Read about the softwares (see tutorials) beforehand.
- Expect a lot more than 4 hours for the exercises.
- Go through all the lectures as fast as you can after attending them so you can get back to the teachers with questions.
- Start study in time, lots of content.
- Work regularly, do a synthesis after each lecture.
- Go to the teacher and specifically ask what they want.
- Keep up from the beginning and work actively during the exercise.
- Don't be afraid to ask, the teachers always help!
- Discuss things with classmates.
- Don't know because I still haven't figured out how to learn all parts of the course.
- Borrow the course literature as it's only used by 1/5 of the course and costs > 600 kr.
- Ask more questions to get familiar with the most useful software. Maybe some labs were too guided
- Try to find the info on youtube or whatever if you do not understand the explanations the teachers give
- I really hope they change the course setup before new students start
- The book is good, spend more time on new aspects.
- Combination of theory and experiments.
- The lectures alone are not enough to study. Thoroughly analyze the objectives with their corresponding professors to discover what they want you to be able to do on an exam.
- Begin with the study questions 3 weeks before exam. Study together
- Start study immediately.
- Study early, a lot to learn.