

Course Analysis

EQ2310 Digital Communications

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Course Data

Course name	Digital Communications
Course code	EQ2310
Credits	9 cu
Prerequisites	EQ1220/EQ1270 Signal theory, or equivalent.
Term	HT22, P2 and VT23, P3
Participation	45 registered students Targeted student groups: TINNM, TSCRM, TEBSM, TIVNM
Teacher	Ragnar Thobaben (course responsible, examiner) Email: ragnart@kth.se
TAs	Amirreza Zamanisiboni (tutorials) Email: amizam@kth.se Neelabhro Roy (lab) Email: nroy@kth.se
Lectures	14 lectures, 2h per lecture
Tutorials	14 tutorials, 2h per tutorial
Examination	TEN1, 7.5 cu, grades A-F – Continuous examination and written exam, 43 of 45 students passed PRO1, 1.5 cu, pass/fail grades – Project assignment, 44 of 44 students passed LAB1, 0.5 cu, pass/fail grades – Lab session, 44 of 44 students
Completion rate	43 of 45 students

Background

The course Digital Communications is a well established fundamentals course that is annually offered by the Division of Information Science and Engineering at the EECS School. Between 2010 and 2018, the course has been offered by Prof. Lars Kildehøj. In 2019, Assoc. Prof. Ragnar Thobaben has taken over the course responsibility. The course is offered to first-year Master students from the Master programmes TINNM, TSCRM, TEBSM, TIVNM, and it is usually followed by around 30-40 students per year on average. It is a mandatory course in TINNM and a recommended/optional course in TSCRM, TEBSM, TIVNM. The course gives a broad introduction to the principles of digital communication systems and summarises the underlying theory. Problem formulation and analysis with mathematical models are the most important aspects of the course.

The course goals are as follows; after passing the course, the student should be able to:

1. justify the fact that the implementation and the development of modern communication technology require mathematical modelling and problem solving

2. explain basic principles and theoretical concepts behind different technologies in modern digital communications, especially in modulation and detection, channel modeling, carrier modulation, channel coding and error protection
3. formulate a mathematical model that is applicable and relevant for a given problem in the area
4. use a given or individually formulated mathematical model for solving a given technical problem in the area and analyse the result and its reasonableness
5. compare different technologies in modern digital communication techniques, contrast different technologies against one another and assess the suitability of individual technologies in different situations
6. carry out, analyse and report simple hardware based experiments in the area
7. develop simple programme code, e.g., by means of the tool Matlab, and use this code to simulate and analyse problems in the area, and report the implementation and the result.

The course is based on the textbook “Fundamentals of Digital Communications,” Upamanyu Madhow, Cambridge 2008.

Course Design

The course consists of 14 lectures and 14 tutorial sessions in Period 2 as well as a small project and a lab in the beginning of Period 3. The lectures convey the main content of the course. Since HT20, pre-recorded lecture material for all lectures exists and is provided to the students for preparation before the lectures and for following up after the lectures. The students are encouraged to complete reading assignments before the lectures, and Canvas quizzes are available to provide students with first feedback on their initial understanding. The tutorial sessions provide additional examples and focus on mathematical problem solving. In the project, the students implement a simple communication system in Matlab and compare the performance obtained by simulations with a mathematical model, and in the lab assignment, the students conduct simple experiments on a USRP software defined radio platform.

Since HT20, the examination of the course is based on continuous examination and a 5h written exam at the end of Period 2. The continuous examination consists of:

- **Essay (ES):** The essay is linked to ILO-1 and graded with grade a pass/fail grade.
- **Oral Presentation (OP):** The oral presentation is linked to ILO-2 and graded with grades C, E, and F.
- **Homework Assignment 1 and 2 (HW1+2):** The homework assignments are linked to ILO-3 to 5 and graded with grades C, E, and F.

The written exam (WE) links to ILO-4 and is graded with grades A, C, or F. The grades from the essay, the oral presentation, and the homework assignments are reported together with the grade from the written exam in TEN1 as specified in Table 1.

Grade TEN1	Requirement
A	<ul style="list-style-type: none"> WE passed with grade A OP, HW1, HW2 are all passed with grade C ES passed with grade P
B	<ul style="list-style-type: none"> WE passed with grade A OP, HW1, HW2 passed, and at most two of them are passed with grade C ES passed with grade P <ul style="list-style-type: none"> WE passed with grade C OP, HW1, HW2 are all passed with grade C ES passed with grade P
C	<ul style="list-style-type: none"> WE passed with grade C OP, HW1, HW2 passed, and two of them are passed with grade C ES passed with grade P
D	<ul style="list-style-type: none"> WE passed with grade C OP, HW1, HW2 passed, and one of them is passed with grade C ES passed with grade P <ul style="list-style-type: none"> WE failed with grade F (or not attended) OP, HW1, HW2 are all passed with grade C ES passed with grade P
E	<ul style="list-style-type: none"> WE failed with grade F (or not attended) OP, HW1, HW2 are passed, and at most two of them is passed with grade C ES passed with grade P
FX	<ul style="list-style-type: none"> One of OP, HW1, HW2, ES is failed with grade F
F	<ul style="list-style-type: none"> Two or more of OP, HW1, HW2, ES are failed with grade F

Changes and Updates in HT22: As pointed out in the course analysis for HT21, we have adjusted the tutorial format to give students the opportunity to solve problems on their own and receive feedback without being graded. This has been achieved by allocating roughly 30 min per tutorial for this purpose and providing students with problems for problem solving in smaller groups, supported by the TA, that are related to concepts covered in previous tutorial sessions. In this way, students test their level of understanding in a collaborative setting and receive feedback on their understanding and progress without being graded. In addition, we moved the lab and project assignments to the beginning of Period 3, as suggested by students in earlier course rounds.

Planned Changes That Have not Been Implemented in HT22: In the course analysis for HT21, a review of the course content has been suggested. We decided to not remove any content from the course in this round, and instead to use lecture videos from previous years strategically to offload the lectures and to refer to the lecture videos for additional details.

Student Performance in HT22

Table 2 shows the distribution of final grades in HT22 (aggregated results from the first exam in January and the re-exam in March) and the grades from HT18 – HT21 for comparison. 25 of 45 students chose to attend the written exam in order to acquire a higher grade A, B, or C. 21 of these 25 students passed the written exam with grade C or A. Compared to previous years, we can see that the distribution of grades A-D is more uniform and that there is a larger number of students who received grade E. Possible explanations are that the grading of the oral presentations was less generous in this course round, acquiring grade C in the oral presentation and all homework projects is required to acquire the overall grade D (in previous rounds only two out of the three assignments had to be passed with grade C), and only few students chose to improve their grades for the oral presentation during the re-exam period. That is, six of the 14 students who received grade E could have easily improved to grade D with very little extra effort but did not choose to.

Table 2: Distribution of final grades in HT20 (30 students in total), HT19 (27 students in total) and HT18 (39 students in total).

	A	B	C	D	E	Fx	F
HT22	6	8	7	8	14	-	2
HT21	9	6	1	21	1	-	-
HT20	3	4	3	14	1	-	5
HT19	8	4	2	2	2	1	8
HT18	7	5	12	4	5	-	6

Course Evaluation

The course was evaluated using the online system provided by KTH social. The course evaluation was anonymous and based on the standard learning experience questionnaire used at KTH. The course evaluation was open in the first half of February, after the lab in Period 3 was completed. **13 of 45 students participated in the course evaluation**, which is comparable to the previous course round.

Summary Generally, the answers to the questions in the course evaluation were very positive and very similar to responses in previous years. Most of the students gave very positive or at least neutral marks, and only in very few cases a negative mark was given by an individual student as it seems. A summary of the average responses is shown in Figure 1(b) together with the summary of the previous course round in Figure 1(b). The dimensions are explained in the following: The students felt that they worked with interesting issues (dimension 1), the course was challenging in a stimulating way (dimension 4), they were able to learn from concrete examples that they could relate to (dimension 10), understanding of key concepts had high priority (dimension 11), they were able to practice and receive feedback without being graded (dimension 15), the assessment on the course was fair and honest (dimension 16), their background was appropriate (dimension 17), the course activities enabled them to learn in different ways (dimension 19), they were able to learn by collaborating and discussing with others (dimension 21), and they were able to get support if they needed it (dimension 22). The learning outcomes were clear, and the students felt that the course design helped them in reaching the goals (dimension 7 and 12).

The responses left in the free-text comments confirm the overall very positive feedback by the students. The course is perceived as very well organized and with a reasonable workload, the continuous examination is highly appreciated, the tutorials are helpful, the teachers are helpful, and the lab is fun. To improve the course, the students suggest to expand the quizzes, to add quizzes after the lecture, to add more exercises, and to allow students to discuss when preparing the homework problems. The students also comment on the low rate of in-class participation, which in their view may be due to scheduling issues; some of the lectures and tutorials were scheduled at 8:00 and this course competed with another course that also required a lot of attention from the students.

Workload in P2 The course credits of 7.5 hp in P2 translate into an expected full-time workload of 5 weeks and an average workload of roughly 22 hours per week over a 9-week period. The responses by the students show that roughly half of the students stayed in the range of 6-17 hours per week, while 25% spent less than 5 hours per week and another 25% spent 24-26 hours per week on the course. This suggests that most students spend notably less time on the course as the course credits of 7.5 hp suggest.

Personal Reflection

The course appears to be in a very stable state. As we can see from Figure 1 the average responses are very similar to previous years with some minor variations here and there. It appears that the adjustment of the tutorials had a positive effect since there are no complaints on the tutorial at all, and the responses in dimension 15 have slightly improved. The small adjustments to the grading scheme also lead to more uniform distribution of grades. From a teacher's perspective, the notable low participation rate in the lectures and the lack of ambition (only roughly half of the students strive for a higher grade) are concerning. Nevertheless, teaching the course is very fun since the concepts taught are very fundamental and widely applicable.

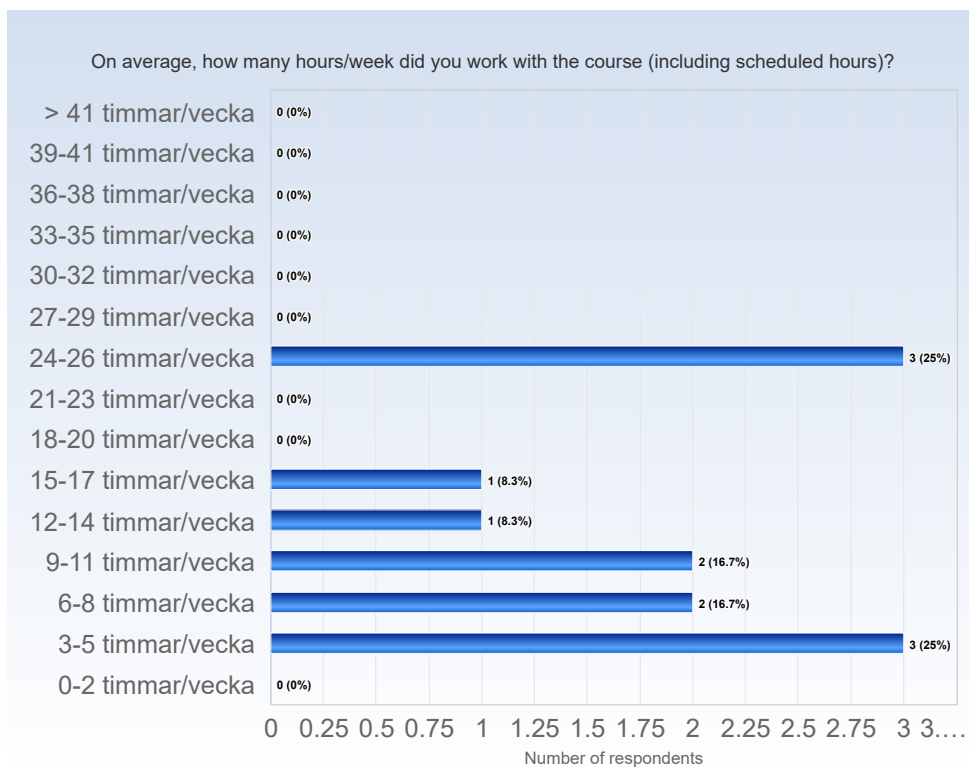
Conclusions and Next Steps

All in all, the course is positively received and in a very stable state. The students perform well, even though as a teacher I would hope for more ambition among the students. There are no urgent issues in the course that need to be fixed from a course design perspective. However, it needs to be investigated how the availability of generative AI tools like Chat-GPT will affect the continuous examination. Since it also has been noted that students prioritise courses with continuous examination during the lecture period and focus on courses with traditional exams during the exam period, we will have a review of the continuous examination in order to evaluate how it can be extended and improved in a trustful manner so that it is robust against the advent of new generative AI tools in the future and less weight is put on the final exam.

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Antal responder: 46
 Antal svar: 13
 Svarsfrekvens: 28,26 %

ESTIMATED WORKLOAD



Comments

Comments (I worked: 3-5 timmar/vecka)

Doing the course material throughout the week

I think the quizzes after lectures could be more effective, instead of before lectures. It helps us understand the abstract concepts better. More work hours will be there.

Comments (I worked: 6-8 timmar/vecka)

The content of the course is vast and requires in-depth understanding, but the teacher delivers them in a hierarchical way and made it easier to memorize.

Comments (I worked: 12-14 timmar/vecka)

Nice

Comments (I worked: 24-26 timmar/vecka)

Kinda hard subject but fun and rewarding

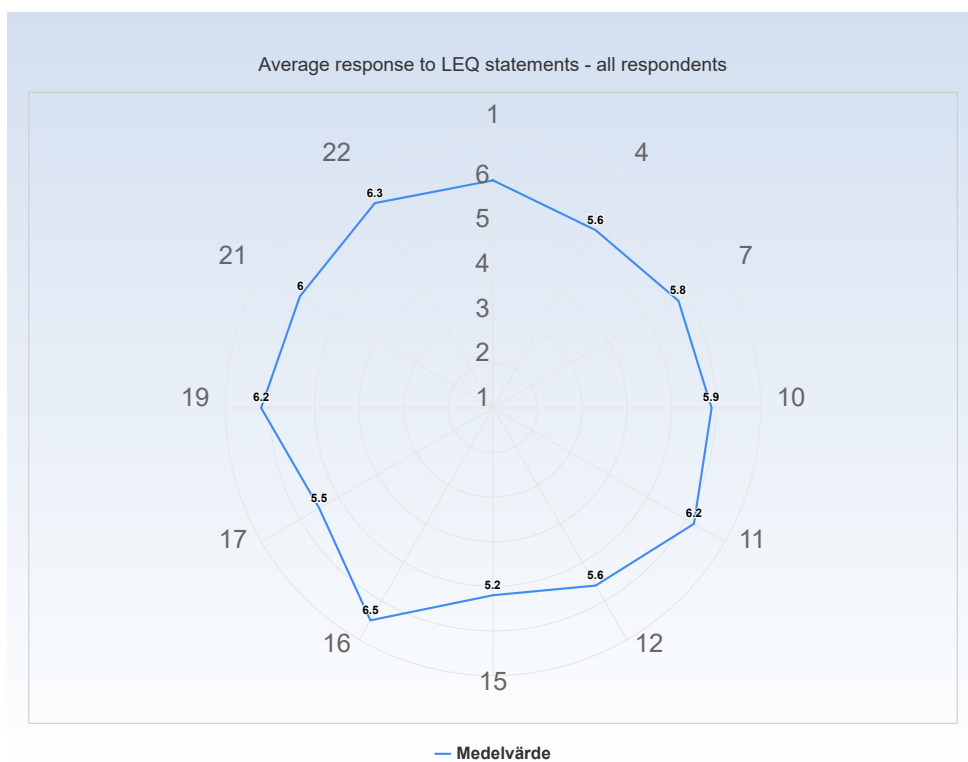
Overall very reasonable workload, the first homework assignment did, however, take more time than anticipated (around 30 hours). The subsequent homework assignment was on the other hand very reasonable ni workload.

LEARNING EXPERIENCE

The polar diagrams below show the average response to the LEQ statements for different groups of respondents (only valid responses are included). The scale that is used in the diagrams is defined by:

- 1 = No, I strongly disagree with the statement
- 4 = I am neutral to the statement
- 7 = Yes, I strongly agree with the statement

Note! A group has to include at least 3 respondents in order to appear in a diagram.



KTH Learning Experience Questionnaire v3.1.4**Meaningfulness - emotional level***Stimulating tasks*

1. I worked with interesting issues (a)

Exploration and own experience

2. I explored parts of the subject on my own (a)
3. I was able to learn by trying out my own ideas (b)

Challenge

4. The course was challenging in a stimulating way (c)

Belonging

5. I felt togetherness with others on the course (d)
6. The atmosphere on the course was open and inclusive (d)

Comprehensibility - cognitive level*Clear goals and organization*

7. The intended learning outcomes helped me to understand what I was expected to achieve (e)
8. The course was organized in a way that supported my learning (e)

Understanding of subject matter

- 9. I understood what the teachers were talking about (f)
- 10. I was able to learn from concrete examples that I could relate to (g)
- 11. Understanding of key concepts had high priority (h)

Constructive alignment

- 12. The course activities helped me to achieve the intended learning outcomes efficiently (i)
- 13. I understood what I was expected to learn in order to obtain a certain grade (i)

Feedback and security

- 14. I received regular feedback that helped me to see my progress (j)
- 15. I could practice and receive feedback without being graded (j)
- 16. The assessment on the course was fair and honest (k)

Manageability - instrumental level*Sufficient background knowledge*

- 17. My background knowledge was sufficient to follow the course (f)

Time to reflect

- 18. I regularly spent time to reflect on what I learned (l)

Variation and participation

- 19. The course activities enabled me to learn in different ways (m)
- 20. I had opportunities to influence the course activities (m)

Collaboration

- 21. I was able to learn by collaborating and discussing with others (n)

Support

22. I was able to get support if I needed it (c)

Learning factors from the literature that LEQ intends to examine

We tend to learn most effectively (in ways that make a sustained, substantial, and positive influence on the way we think, reflect, act or feel) when:

- a) We are trying to answer questions, solve problems or acquire skills that we find interesting, exciting or important
- b) We are able to speculate, test ideas (intellectually or practically) and learn from experience, even before we know much about the subject
- c) We are able to do so in a challenging and at the same time supportive environment
- d) We feel that we are part of a community and believe that other people have confidence in our ability to learn
- e) We understand the meaning of the intended learning outcomes, how the environment is organized, and what is expected of us
- f) We have adequate prior knowledge to deal with the current learning situation
- g) We are able to learn inductively by moving from concrete examples and experiences to general principles, rather than the reverse
- h) We are challenged to develop a true understanding of key concepts and gradually create a coherent whole from the content
- i) We believe that the work we are expected to do will help us to achieve the intended learning outcomes
- j) We are able to try, fail, and receive feedback before, and separate from, each summative assessment of our efforts

k) We believe that our work will be considered in an honest and fair way

l) We have sufficient time for learning and devote the time needed to do so

m) We believe that we have control over our own learning, and not that we are being manipulated

n) We are able to collaborate with other learners struggling with the same problems

Literature

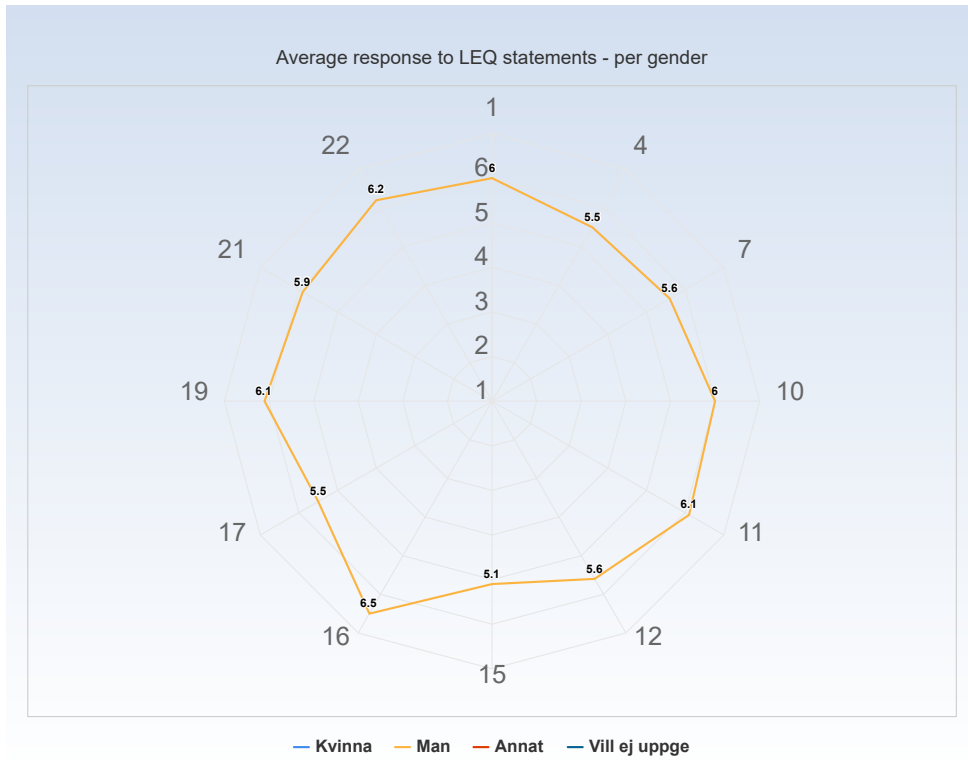
Bain, K. (2004). *What the Best College Teachers Do*, Chapter 5, pp. 98-134. Cambridge: Harvard University Press.

Biggs J. & Tang, C. (2011). *Teaching for Quality Learning at University*, Chapter 6, pp. 95-110. Maidenhead: McGraw Hill.

Elmgren, M. & Henriksson, A-S. (2014). *Academic Teaching*, Chapter 3, pp. 57-72. Lund: Studentlitteratur.

Kember, K. & McNaught, C. (2007). *Enhancing University Teaching: Lessons from Research into Award-Winning Teachers*, Chapter 5, pp. 31-40. Abingdon: Routledge.

Ramsden, P. (2003). *Learning to Teach in Higher Education*, Chapter 6, pp. 84-105. New York: RoutledgeFalmer.

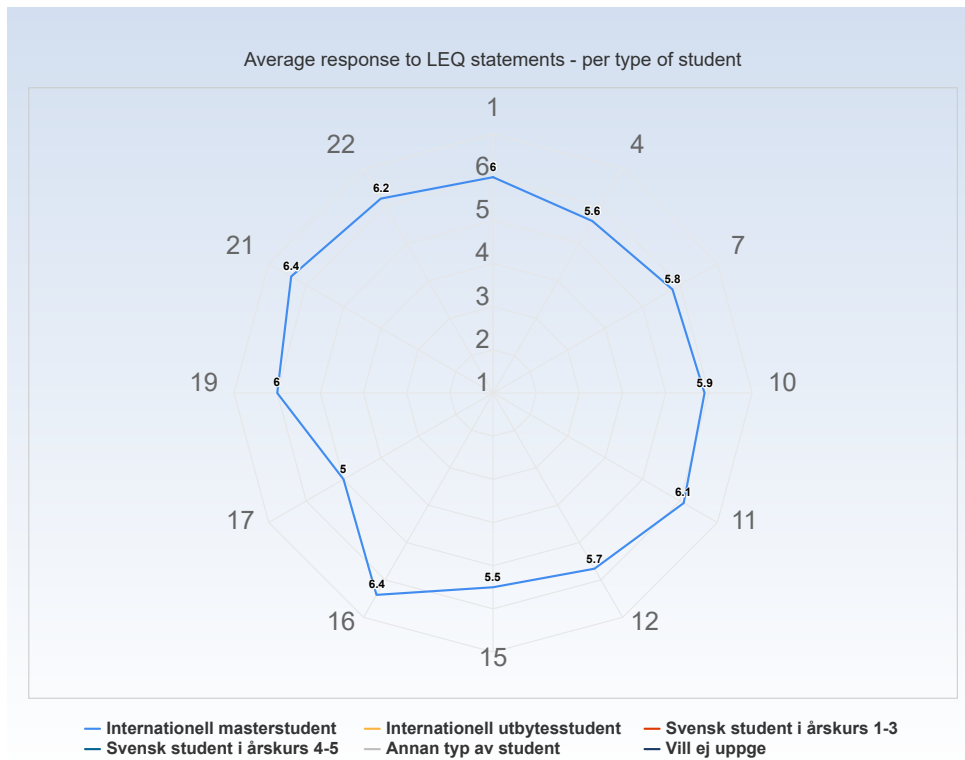


Comments

Comments (I am: Man)

Good

Nothing.

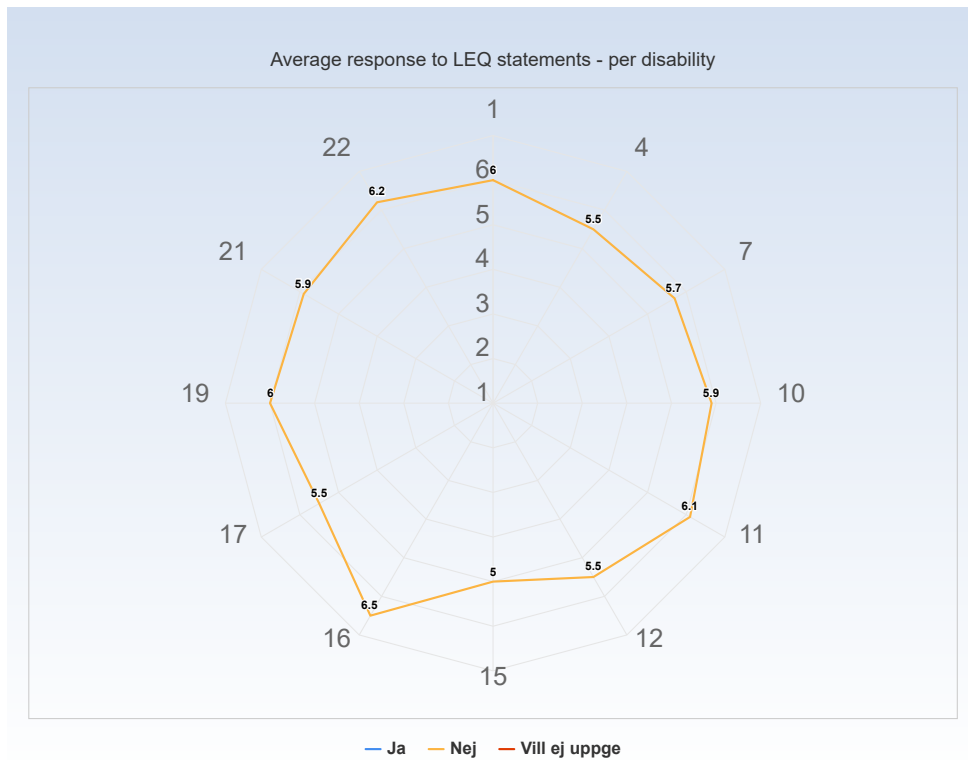


Comments

Comments (I am: Internationell masterstudent)

Good

Nothing.



Comments

Comments (My response was: Ja)
 dyslexia. No big issues

Comments (My response was: Nej)
 Nothing
 Nothing.

GENERAL QUESTIONS

What was the best aspect of the course?

What was the best aspect of the course? (I worked: 3-5 timmar/vecka)

Very organised
Online and offline teaching method.
Low workload.

What was the best aspect of the course? (I worked: 6-8 timmar/vecka)

Practical in multiple ways, incl. lectures, exercises, lab, project. The continuous examination is great.

What was the best aspect of the course? (I worked: 9-11 timmar/vecka)

Lab and project
Other than lectures, the tutorials are also really helping!

What was the best aspect of the course? (I worked: 12-14 timmar/vecka)

All are good

What was the best aspect of the course? (I worked: 15-17 timmar/vecka)

The teacher is very helpful.

What was the best aspect of the course? (I worked: 24-26 timmar/vecka)

Fun topic with cool applications
The homework assignments were very good in helping to learn the concepts and how they related to each other.
Continuous examination

What would you suggest to improve?

What would you suggest to improve? (I worked: 3-5 timmar/vecka)

Kind think of anything
Some quizzes after lectures could be added, instead of before lectures. The continuous examinations can remove the video presentation, adding more assignments whose contents are more targeted. (3-4 assignments are more suitable, and the content of each could be a bit less.)
More assignments at canvas to let student be aware of how deeper he/she should go.

What would you suggest to improve? (I worked: 6-8 timmar/vecka)

Continuous examination could set up chances for those who want to make up and improve their grade, maybe.

What would you suggest to improve? (I worked: 9-11 timmar/vecka)

Remove some modules from the coursework.
Sorry I can't give some concrete advice.

What would you suggest to improve? (I worked: 12-14 timmar/vecka)

Nothing

What would you suggest to improve? (I worked: 24-26 timmar/vecka)

Very much math. So I did not get a good intuition about QPSK vs QAM (and what systems use which for example) for example without doing 1 full page of calculations.
The homework assignments is were I probably got the best understanding for the different concepts. Not being allowed to discuss the problems with other students made it more difficult to bounce ideas around for how one should solve and understand the different problems. This could be improved upon by loosening up said restrictions a bit, while still maintaining rules to make sure that everyone understands and do their own solutions.
More exercises. It is nice to have more practical examples rather than theory since the online lectures are enough for it.

What advice would you like to give to future participants?

What advice would you like to give to future participants? (I worked: 3-5 timmar/vecka)

No idea
Please participate in more tutorials.
Practice more calculation ability.

What advice would you like to give to future participants? (I worked: 6-8 timmar/vecka)

Ragnar is fun and great. Courses are of medium difficulty.

What advice would you like to give to future participants? (I worked: 9-11 timmar/vecka)

Tutorials are helpful for exams.

What advice would you like to give to future participants? (I worked: 12-14 timmar/vecka)

Nothing

What advice would you like to give to future participants? (I worked: 15-17 timmar/vecka)

Work hard from the beginning.

What advice would you like to give to future participants? (I worked: 24-26 timmar/vecka)

Go to the tutorials.

Is there anything else you would like to add?

Is there anything else you would like to add? (I worked: 3-5 timmar/vecka)

No

I think the reason why many students choose not to attend the lectures is that a full schedule. Many students chose a course which also had many lectures and tutorials each week. What's more, DC courses were always scheduled in 8.00-10.00. It's hard to get up early in Stockholm in winter, especially with another course which had many lectures and tutorials each week.

No.

Is there anything else you would like to add? (I worked: 12-14 timmar/vecka)

Nothing

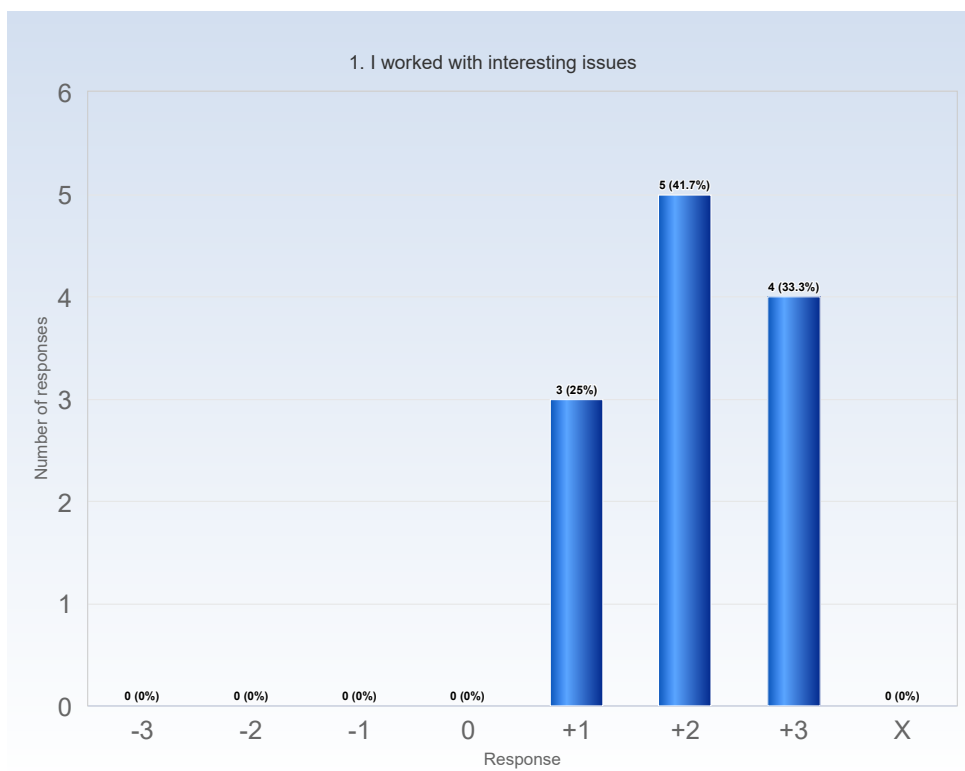
SPECIFIC QUESTIONS

RESPONSE DATA

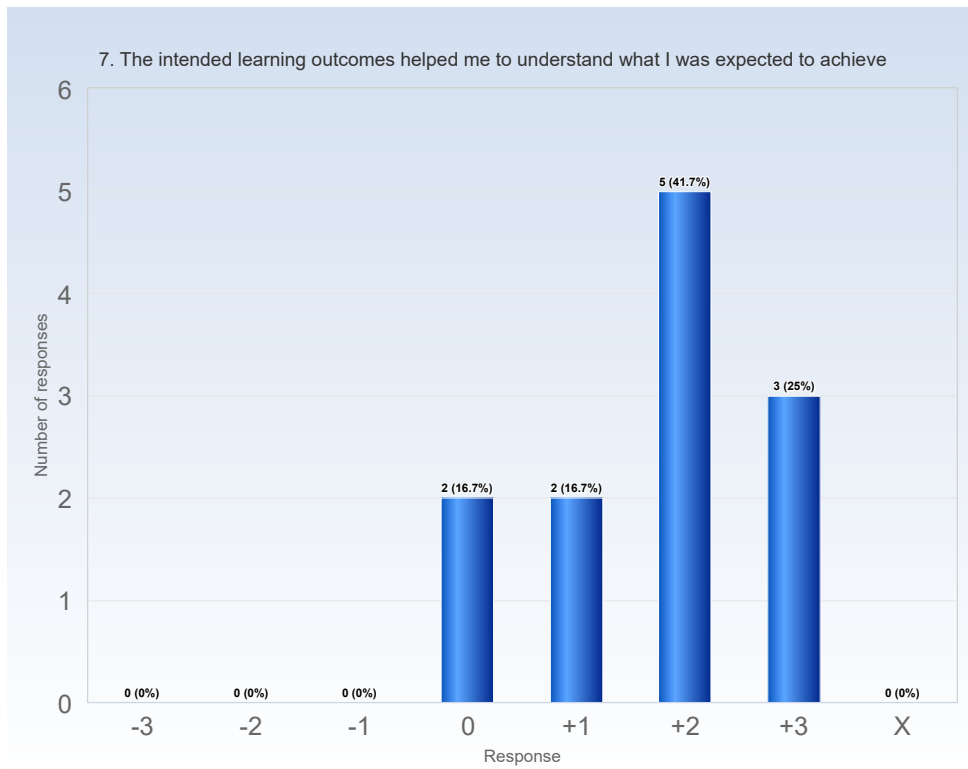
The diagrams below show the detailed response to the LEQ statements. The response scale is defined by:

- 3 = No, I strongly disagree with the statement
- 0 = I am neutral to the statement
- +3 = Yes, I strongly agree with the statement

X = I decline to take a position on the statement



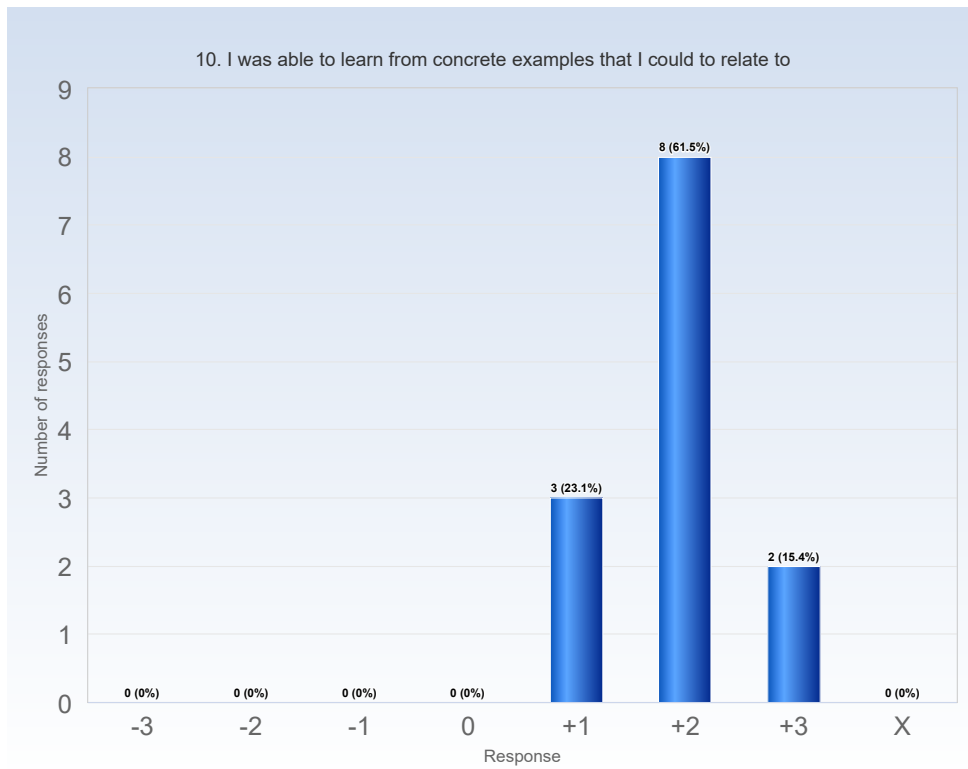




Comments

Comments (My response was: +2)

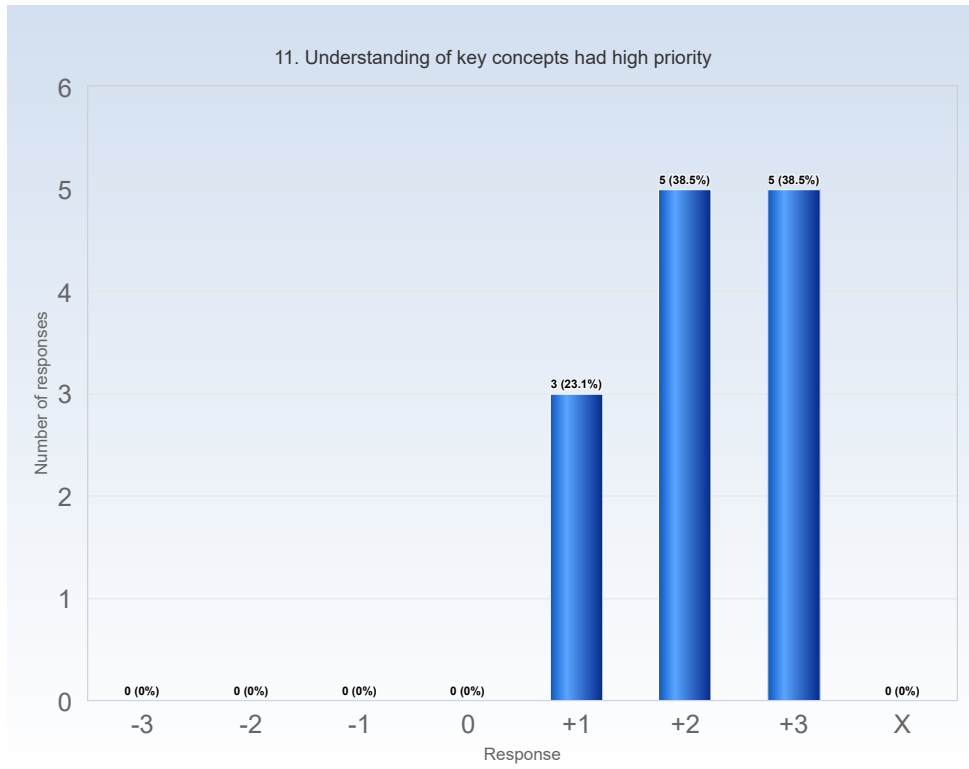
It was hard to understand what they meant before taking the course

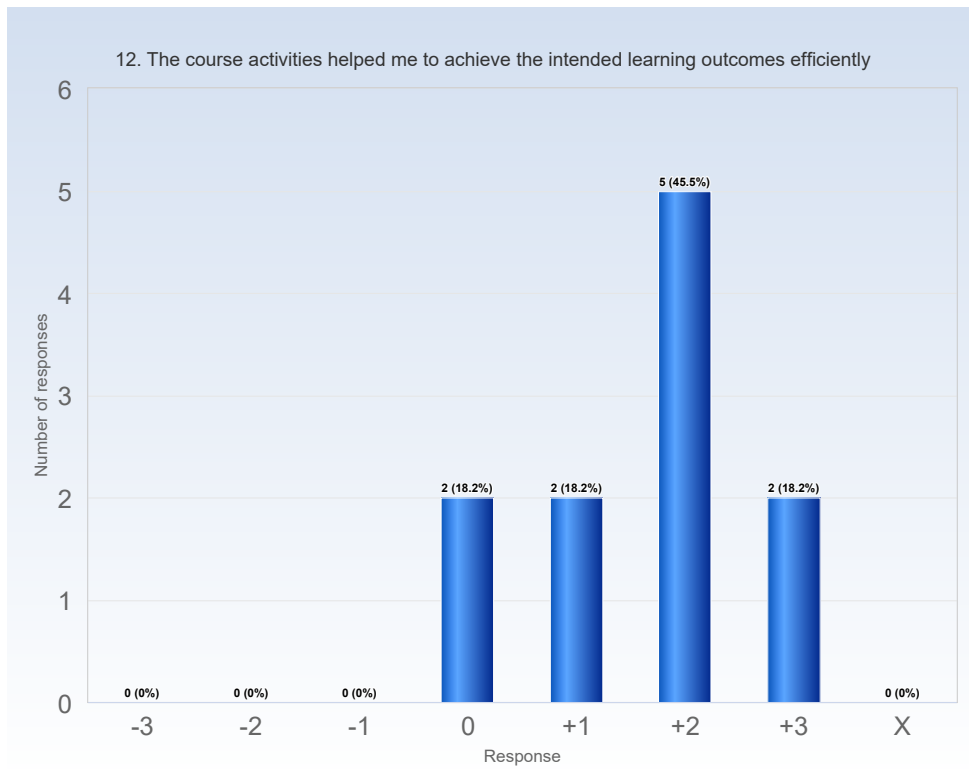


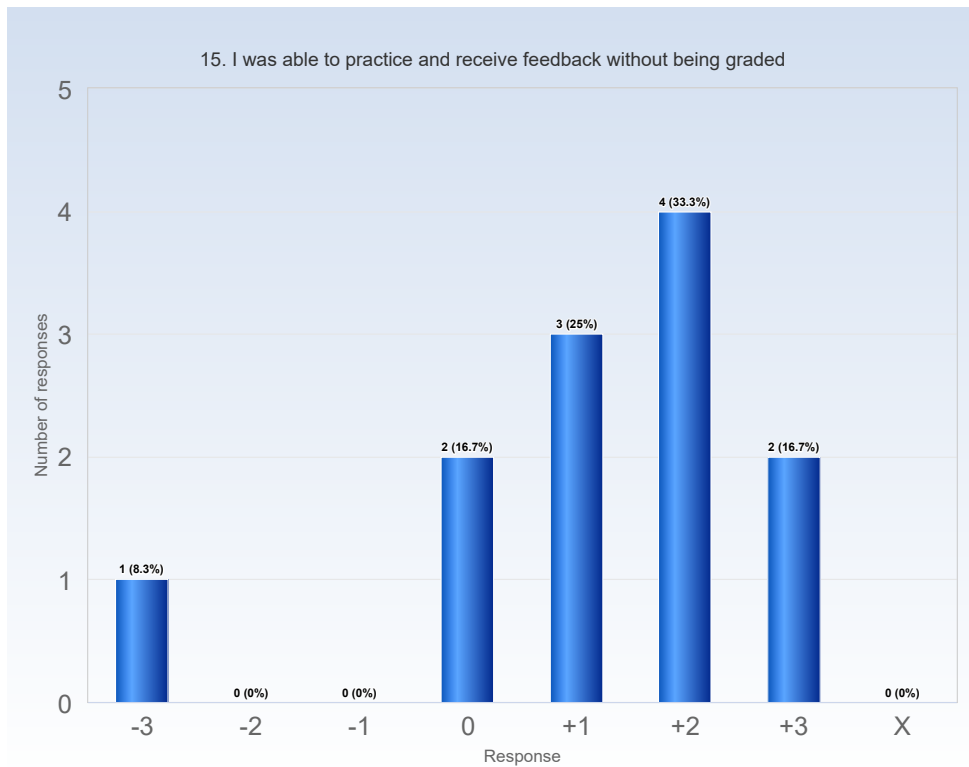
Comments

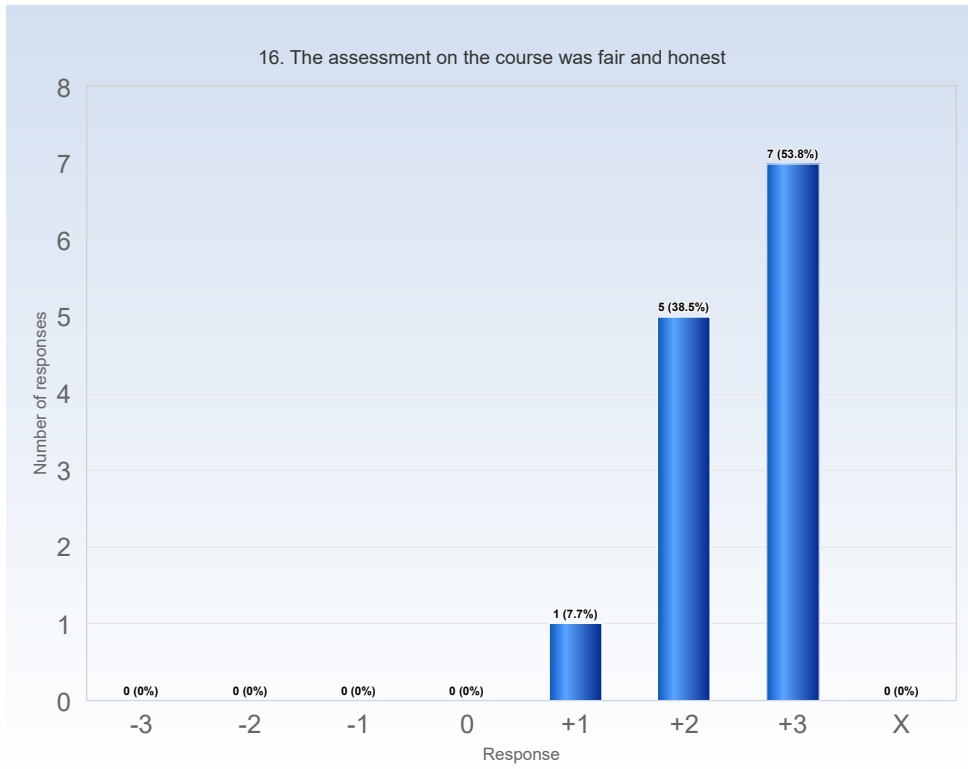
Comments (My response was: +1)

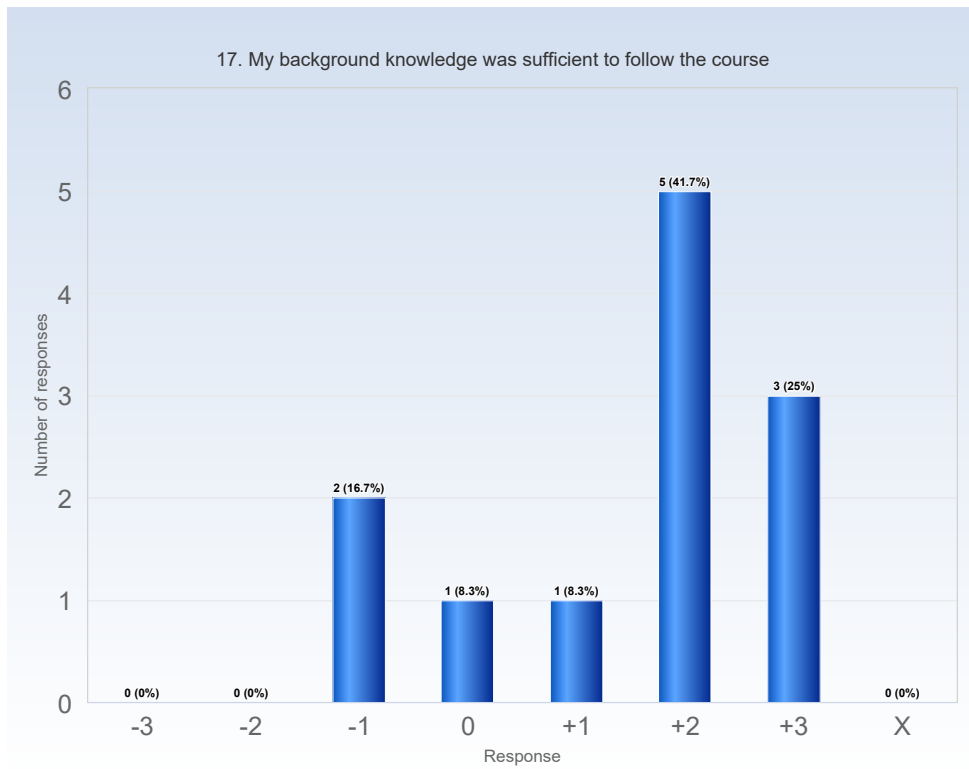
Maybe the question examples given in the lectures could be more related to the exam questions.

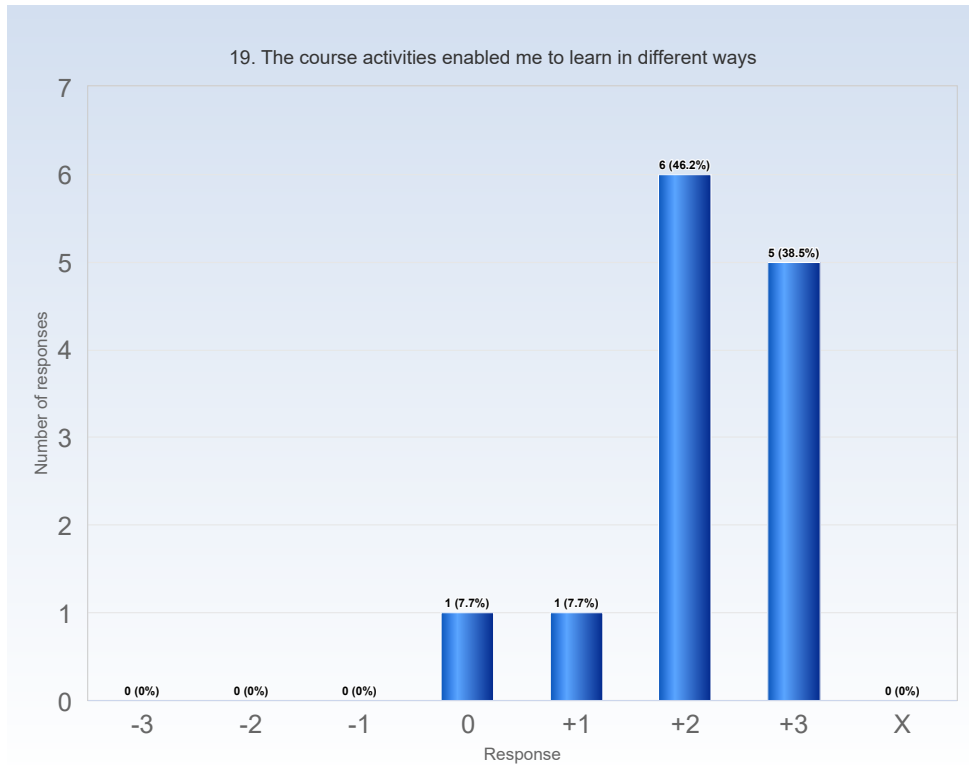










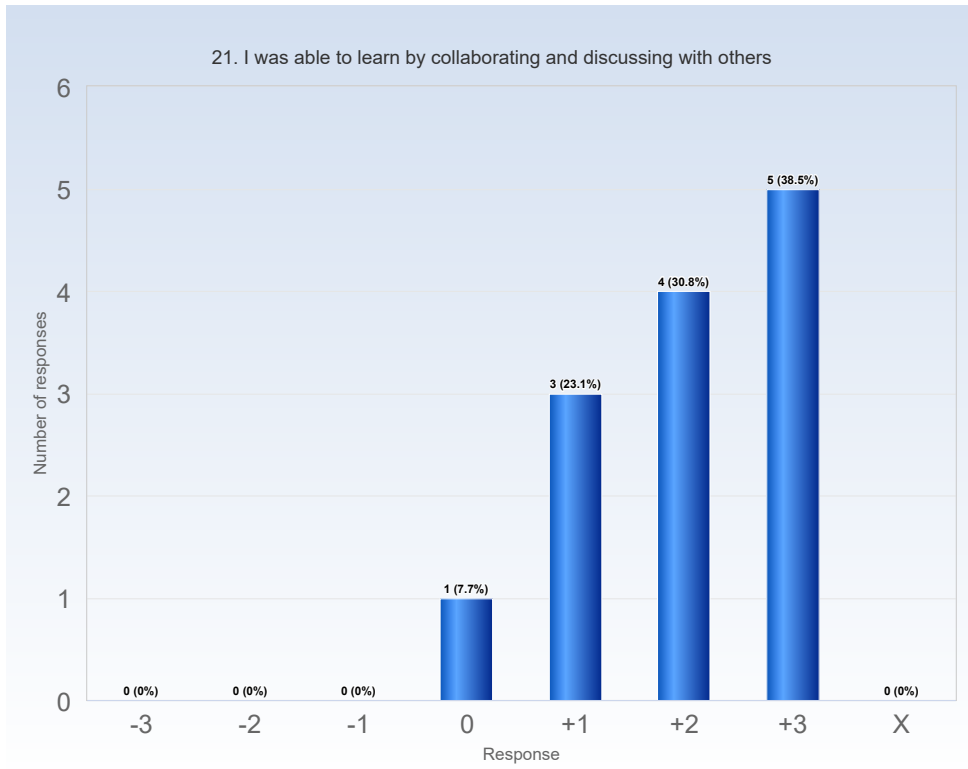


Comments

Comments (My response was: +3)

To bad most of the "fun" stuff was after the exam

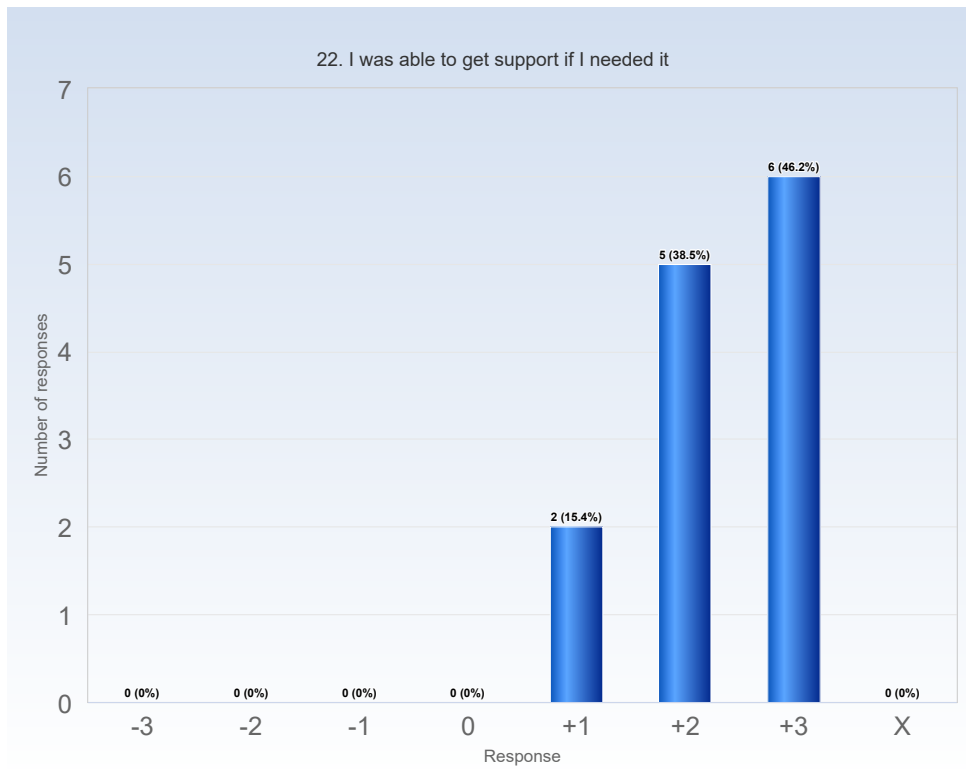
It promoted me to learn harder comparing to last semester.

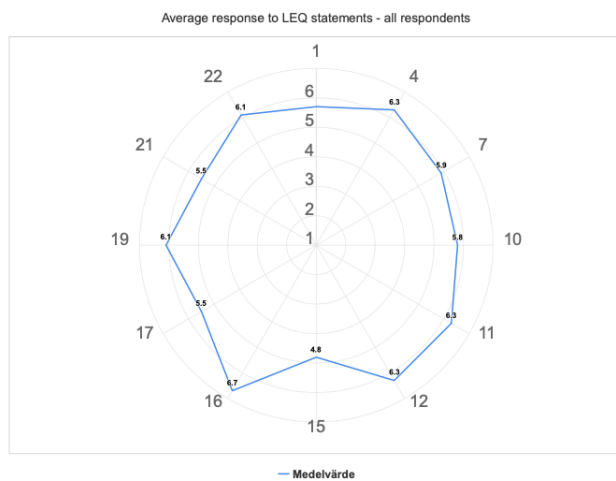


Comments

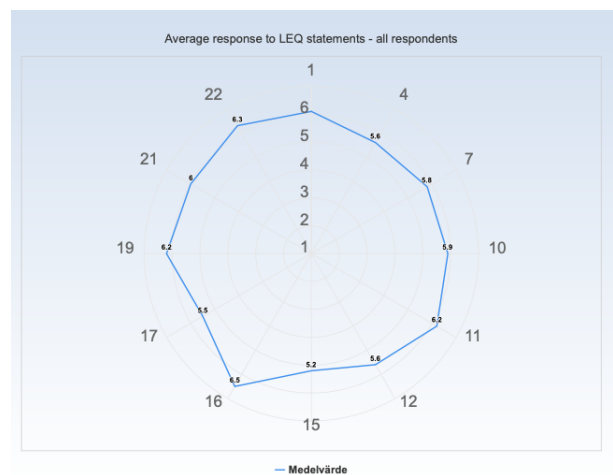
Comments (My response was: +2)

The offline lab is of great fun and left a great impression to me.





(a) HT21



(b) HT22

Figure 1: Average responses to the questions in the course evaluation on a scale from 1 to 7, where 4 corresponds to a neutral response.