

Course Analysis

EQ2310 Digital Communications

Ragnar Thobaben, ISE, EECS, KTH

Course Data

Course name	Digital Communications
Course code	EQ2310
Credits	9 cu
Prerequisites	EQ1220/EQ1270 Signal theory, or equivalent.
Term	HT21, P2 and VT22, P3
Participation	42 registered students, 38 actively participating students Targeted student groups: TINNM, TSCRM, TEBSM, TIVNM
Teacher	Ragnar Thobaben (course responsible, examiner) Email: ragnart@kth.se
TAs	Amirreza Zamanisiboni Email: amizam@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, 38 of 38 students passed PRO1, 1.5 cu, pass/fail grades – Project assignment, 37 of 38 students passed LAB1, 0.5 cu, pass/fail grades – Lab session, 37 of 38 students
Completion rate	37 of 38 students
Student Representatives	Leonhard Grosse, Yuqi Zheng

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 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.

Changes and Updates in HT21: A significant change in the course design and the material was implemented in HT20 with the transition to online teaching and continuous examination. This year, the updated course design with continuous teaching was brought back to the classroom, and only minor adjustments were made to the material.

Table 1: Composition of the grade for TEN1 from the essay, presentation, and homework grades.

Grade TEN1	Requirement		
A	<ul style="list-style-type: none"> WE passed with grade A OP, HW1, HW2 all passed with grade C ES passed with grade P 		
B	<table border="1" style="width: 100%;"> <tr> <td style="width: 50%;"> <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 </td> <td style="width: 50%;"> <ul style="list-style-type: none"> WE passed with grade C OP, HW1, HW2 all passed with grade C ES passed with grade P </td> </tr> </table>	<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 all passed with grade C ES passed with grade P
<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 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 at least two of them are passed with grade C ES passed with grade P 		
D	<table border="1" style="width: 100%;"> <tr> <td style="width: 50%;"> <ul style="list-style-type: none"> WE passed with grade C OP, HW1, HW2 passed, and at most one of them is passed with grade C ES passed with grade P </td> <td style="width: 50%;"> <ul style="list-style-type: none"> WE failed with grade F (or not attended) OP, HW1, HW2 are passed, and at least two of them are passed with grade C ES passed with grade P </td> </tr> </table>	<ul style="list-style-type: none"> WE passed with grade C OP, HW1, HW2 passed, and at most 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 passed, and at least 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 passed, and at most 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 passed, and at least two of them are 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 one 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 		

Planned Changes That Have not Been Implemented in HT21: None.

Student Performance in HT21

Table 2 shows the distribution of final grades in HT21 (aggregated results from the first exam in January and the re-exam in March) and the grades from HT18 – HT20 for comparison. 21 of 38 students chose to attend the written exam in order to acquire a higher grade A, B, or C. 16 of these 21 students passed the written exam with grade C or A. One student who has not passed the course yet, has passed TEN1 and is only missing the project or lab assignment due to exchange studies. Compared to previous years, we can see a similar distribution of grades A and B as in HT18 and HT19 (i.e., the results seem consistent with earlier years before the pandemic). The large number of grade D is due to the fact that many students make an effort on the continuous examination but then decide to not take the written exam to get to higher grades A-C.

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
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 until three weeks after the written exam. **11 of 38 students participated in the course evaluation.** The drop in response rate compared to previous years is due to the fact that in earlier years students have received a fraction of a bonus point on the exam when they filled out the course evaluation. This option has been removed in this 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, and 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). Negative responses by an individual student were given to Question 17 (i.e., appropriate background) and Question 21 (i.e., learn by collaborating and discussing with others), and three students judged the possibility to practice and receive feedback without being graded (Question 15) negatively.

The responses left in the free-text comments confirm the overall very positive feedback by the students. Especially the continuous examination receives a lot of positive feedback; it promotes continuous learning, it provides students with useful examples, and it features a good variation of methods. The students are general happy with the lectures but indicate that the tutorials need improvement. Criticism and suggestions for changes are summarized in the following.

Criticism and Suggestions The students identified the following weak spots in the course and suggest the following updates:

1. **Content of the Course:** As in the previous course round, the students perceive the volume of course content as a challenge and suggest to reduce the course content.
2. **Tutorials:** The students indicate that the tutorials need to be improved, e.g., by making them more interactive and letting students solve problems on their own.

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 with one exception, the students spent between 3 and 20 hours per week, and only in a single case, working hours around 34 hours per week were reported. This is a slight decrease compared to previous year.

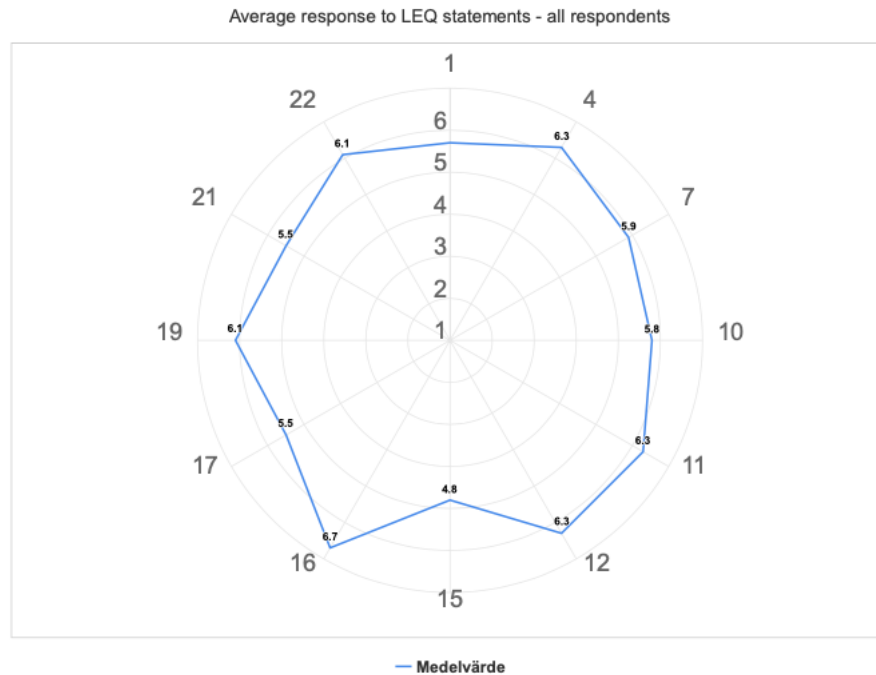


Figure 1: Average responses to the questions in the course evaluation on a scale from 1 to 7, where 4 corresponds to a neutral response.

Feedback from the Student Representatives

The course was perceived from the student side as having a lot of content, which could be slightly reduced. The amount of work was generally seen as fitting, opinions apparently mostly differing depending on students previous knowledge. From the feedback it can be seen that the concept and especially the design of the continuous examination was well received. They considered the continuous learning that was promoted through this approach to be very necessary and helpful. Most students felt that the activities in the course could help them to learn with interest, enthusiasm, and efficiency, such that they were able to master the key concepts of the course well enough and achieve their learning goals. Besides, students thought that they received enough help in the course, including being able to discuss problems with classmates and getting help from the teaching assistant and the professor.

In general, most students that gave feedback about the project and lab part found it to be of very manageable extent, but would have liked the deadlines to be placed earlier in the third period, in order to not have it collide with other course's projects. While the general feedback was mostly very positive, a slight shift can be seen in regards of receiving feedback without being graded, which is due to all assignments being graded and having a direct influence on the final grade. There were no complaints concerning JML guidelines.

Personal Reflection

This year, the course returned to class-room teaching while keeping the continuous examination from the previous course round and offering lecture recordings from last year as backup material. The availability of pre-recorded lectures has certainly contributed to having a lower attendance in class-room; on the other hand, the students that come to class are better prepared, which leads to more interactions between teacher and students (e.g., students ask more and better

questions), which increases the fun and motivation in the classroom. The increased interaction makes it sometimes difficult to get through the lecture material, also since the course covers a lot of material as pointed out above, and in situations where not everything could be covered, lecture recordings were helpful to finish the lecture without rushing (i.e., students are asked to watch the missing part after the lecture). The students indicate that the tutorials can be improved. Here, the teacher agrees in general; however, it also needs to be acknowledged that this year, the workload on the TA has doubled since only one TA was available. One source of frustration from the teachers' perspective is the fact that only a small number of students chooses to take the written exam to get to a higher grade. This lack of ambition is problematic!

Conclusions and Next Steps

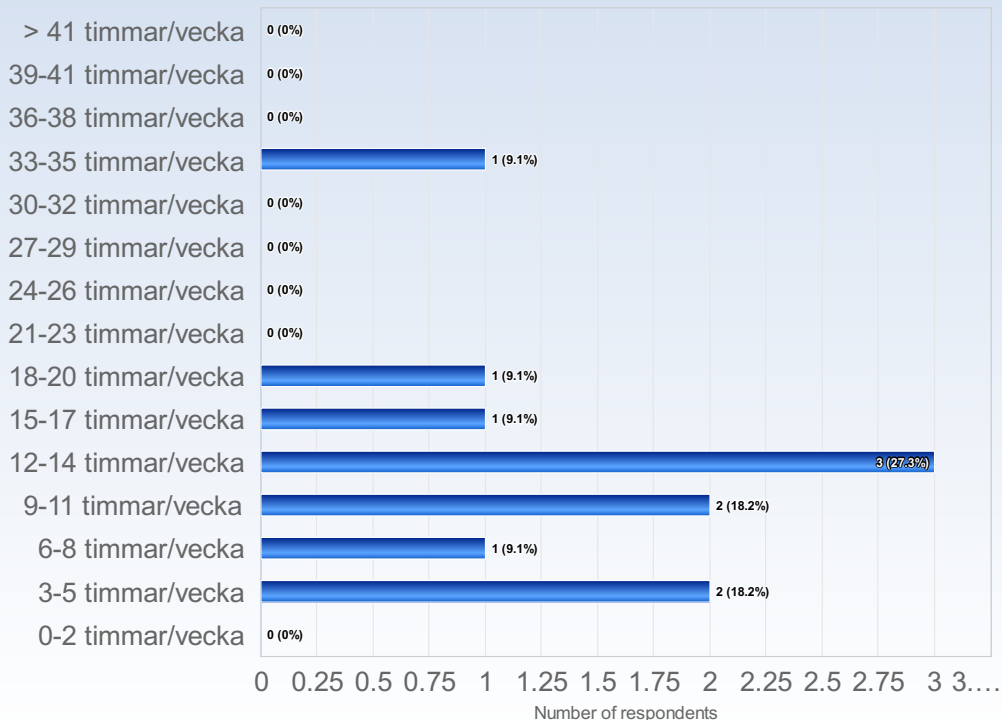
The course has been running very stable over the last few years, with very positive feedback from the students. Nevertheless, the course evaluation indicates two areas for improvement, (1) the large volume of the course content and (2) the tutorials. We will address these issues by reviewing and possibly reorganising the course material such that some advanced topics are delegated to video modules for students who want to dive deep in order to make room in the class-room lectures. We will furthermore review the tutorial structure and try to create opportunities for own problem solving and receiving feedback during the tutorials. To address the issue that only few students take the written exam, we will review and update the composition of the final grade from the different examination activities in order to create a larger incentive for the students to take the written exam. As suggested by the student representatives, we will try to move the schedule for the lab and project in Period 3 to avoid unnecessary collisions with assignments in Period 3.

EQ2310 - 2022-02-02

Antal respondenter: 43
Antal svar: 11
Svarsfrekvens: 25,58 %

ESTIMATED WORKLOAD

On average, how many hours/week did you work with the course (including scheduled hours)?



Comments

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

I think it was quite good schedule wise , the work load was manageable as well.

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

It was good.

Comments (I worked: 9-11 timmar/vecka)

I'm OK with it

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

Not too much work

But the existing homework is really useful

Comments (I worked: 15-17 timmar/vecka)

heavy courseload if you want to keep up with the lectures and do the reading assignments

Comments (I worked: 18-20 timmar/vecka)

The homeworks took a lot of time, can not evaluate the project yet

Comments (I worked: 33-35 timmar/vecka)

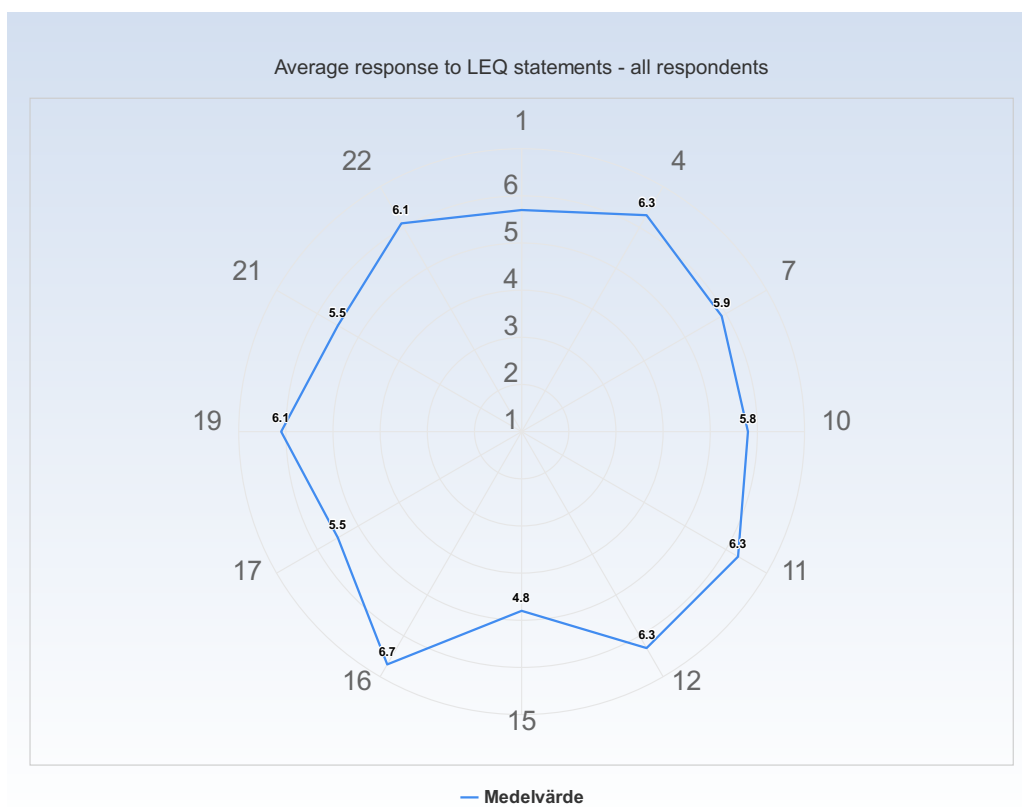
This course has really complex material. 4hours a day to understand the complete concept in all slides is not enough. However, the content is very useful.

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

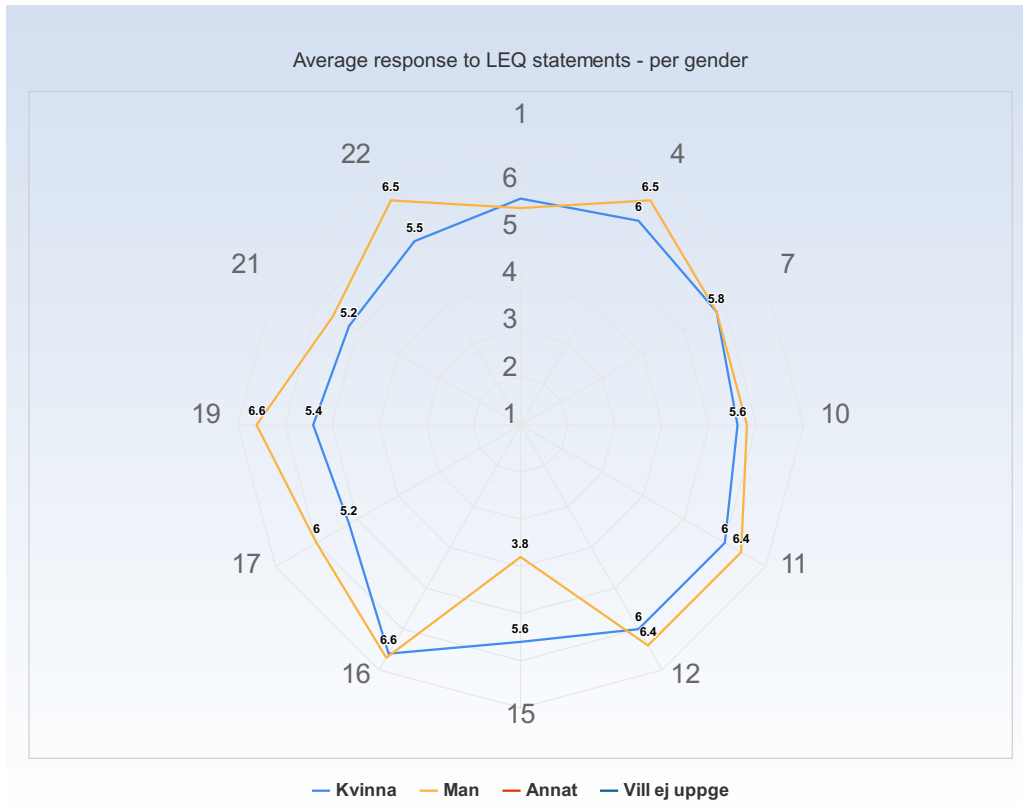
Bain, K. (2004). *What the Best College Teachers Do*, Chapter 5, pp. 98-134. Cambridge: Harvard University Press.

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.

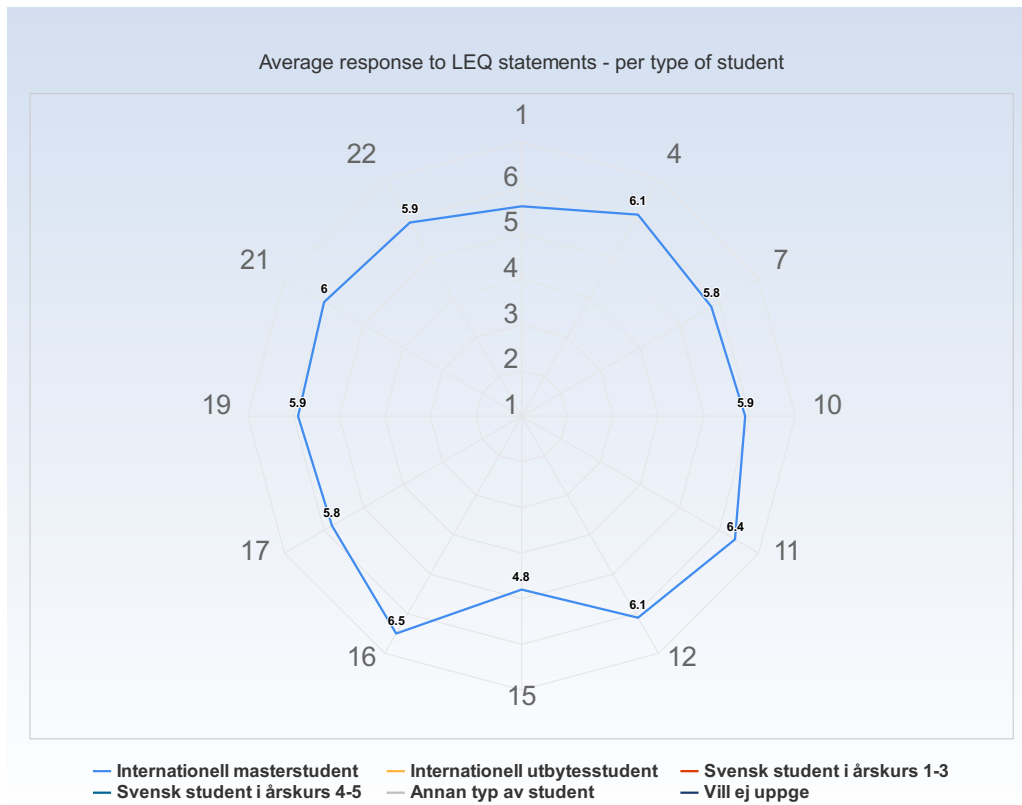
Ramsden, P. (2003). *Learning to Teach in Higher Education*, Chapter 6, pp. 84-105. New York: RoutledgeFalmer.



Comments

Comments (I am: Kvinna)
 Never had any sort of issue

Comments (I am: Man)
 I wasn't the only male. There where other males as well.



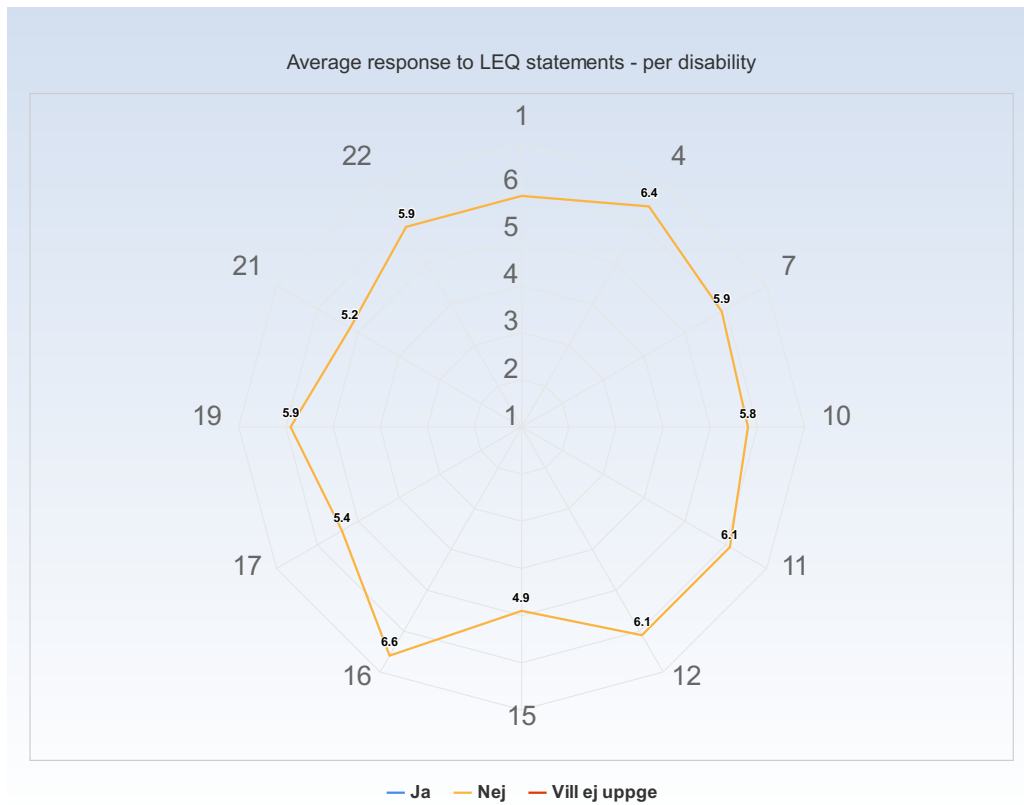
Comments

Comments (I am: Internationell masterstudent)

I am indeed a international master student

I found that the material is broader and deeper version of what I got from bachelor degree in my country

It is a little bit unuseful for me since I have taken much the same course at my university.



Comments

Comments (My response was: Nej)
 at least not to my knowledge

GENERAL QUESTIONS

What was the best aspect of the course?

- What was the best aspect of the course? (I worked: 3-5 timmar/vecka)
I really liked that it was a continuous examination format
- What was the best aspect of the course? (I worked: 6-8 timmar/vecka)
Continuous evaluation.
- What was the best aspect of the course? (I worked: 9-11 timmar/vecka)
The homeworks helped to apply what we learned.
- What was the best aspect of the course? (I worked: 12-14 timmar/vecka)
The homework&test is not about remembering any fomula. It is about understanding. I like it.
- What was the best aspect of the course? (I worked: 15-17 timmar/vecka)
The continuous examination was fair and the problems where interesting with a structure that gave insights on how the principles can be used to solve real problems
- What was the best aspect of the course? (I worked: 18-20 timmar/vecka)
The lectures were very good and I like the continuous examination
- What was the best aspect of the course? (I worked: 33-35 timmar/vecka)
I love the lecturer, but not quite happy with the TA. The same material which confused me has better been explained by the lecturer.

What would you suggest to improve?

- What would you suggest to improve? (I worked: 3-5 timmar/vecka)
I think the amount of content expected to be delivered in a lecture can be reduced
- What would you suggest to improve? (I worked: 6-8 timmar/vecka)
The final exam was designed such that all questions must be answered, this puts pressure.
- What would you suggest to improve? (I worked: 9-11 timmar/vecka)
The tutorials were not much interactive. I'd prefer to have some time to solve the problems myself in class before solving them on the board.
- What would you suggest to improve? (I worked: 12-14 timmar/vecka)
The tutorial session can be improved. Also, the information theory part is interesting but might be too easy so maybe moving it to another comprehensive course is better.
- What would you suggest to improve? (I worked: 15-17 timmar/vecka)
less content, the course is kind of overloaded. Also, an industry/guest lecture would be nice
- What would you suggest to improve? (I worked: 18-20 timmar/vecka)
I would suggest to give more information about when the project and lab in period 3 are going to take place. I thought it was very short on time announcing it a week before since many students are reading more than 100% this period due to this course
- What would you suggest to improve? (I worked: 33-35 timmar/vecka)
I am not a fan of the continuous examination format. Because if students fail in the homework then they fail the entire combination written exam, and oral presentation. I suggest to make the homework treated as bonus point for the exam, not a part of continuous exam.

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)
I think staying on par with the lectures definitely helps to an extent
- What advice would you like to give to future participants? (I worked: 6-8 timmar/vecka)
Study continuously.
- What advice would you like to give to future participants? (I worked: 9-11 timmar/vecka)
Try to solve the tutorials beforehand.
- What advice would you like to give to future participants? (I worked: 12-14 timmar/vecka)
The homework is well designed.
- What advice would you like to give to future participants? (I worked: 18-20 timmar/vecka)
Start with the homeworks on time and take time to understand the basic concepts in the course
- What advice would you like to give to future participants? (I worked: 33-35 timmar/vecka)
Start earlier. Learn every line of equation in the slides and be creative to connect the dot in this lecture

Is there anything else you would like to add?

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

Is there anything else you would like to add? (I worked: 6-8 timmar/vecka)
No

Is there anything else you would like to add? (I worked: 15-17 timmar/vecka)
#freemir

Is there anything else you would like to add? (I worked: 18-20 timmar/vecka)
Really fun and interesting course, Ragnar is a good lecturer

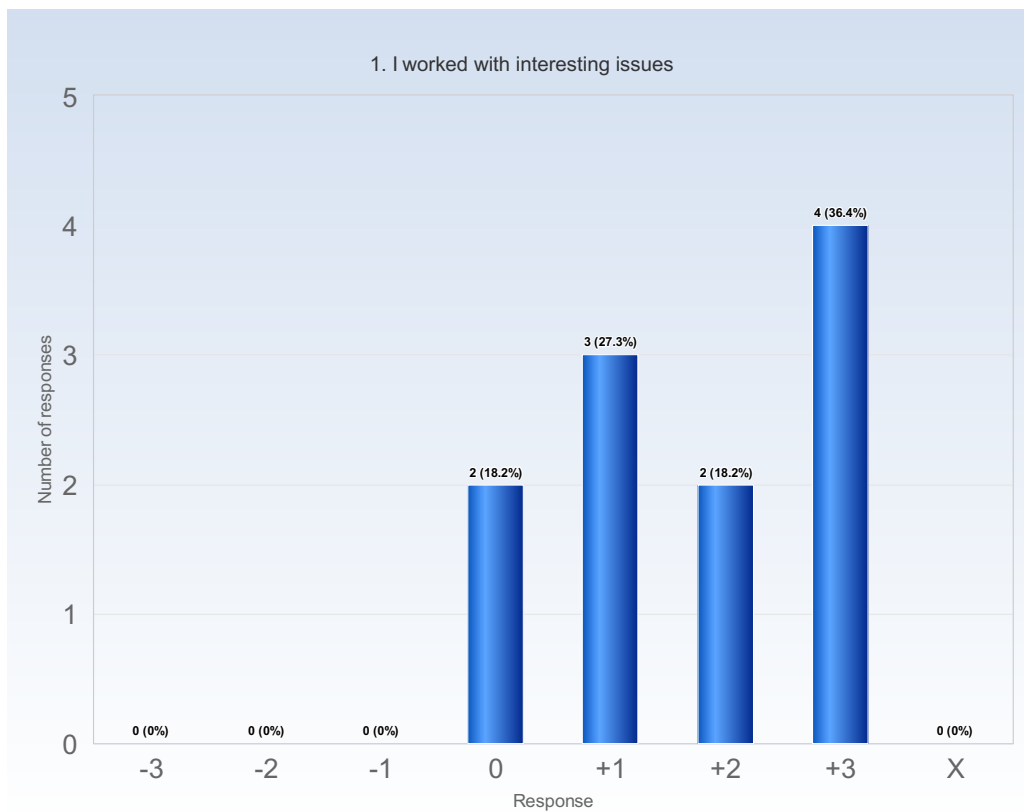
SPECIFIC QUESTIONS

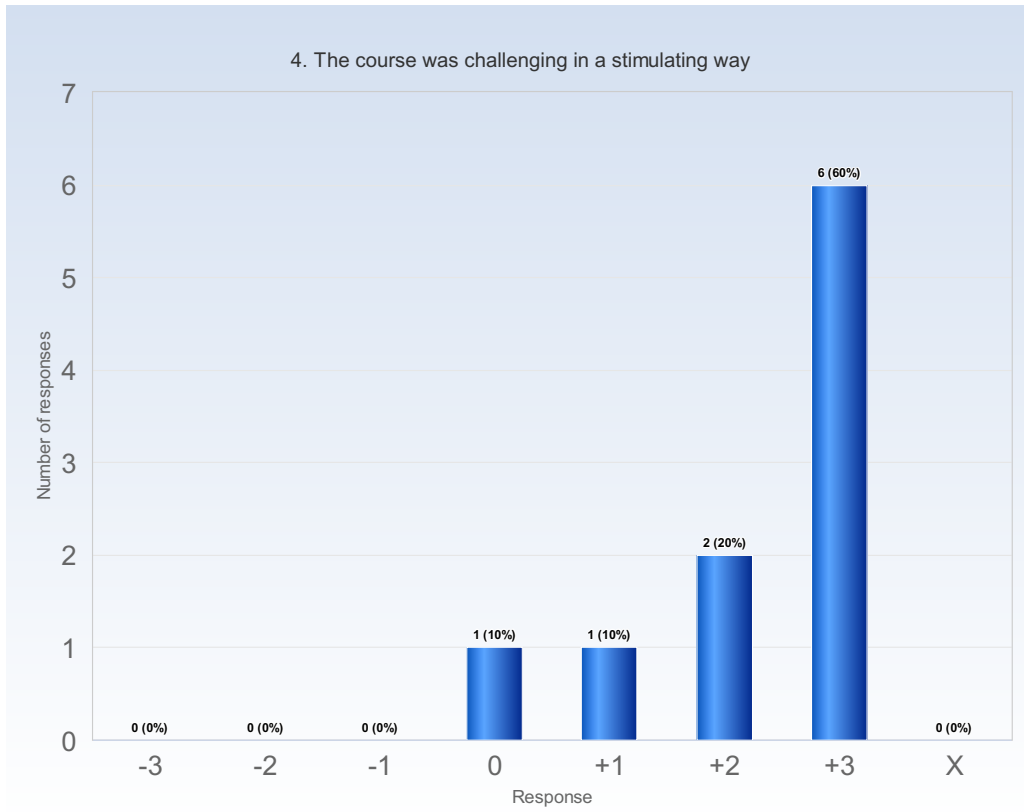
RESPONSE DATA

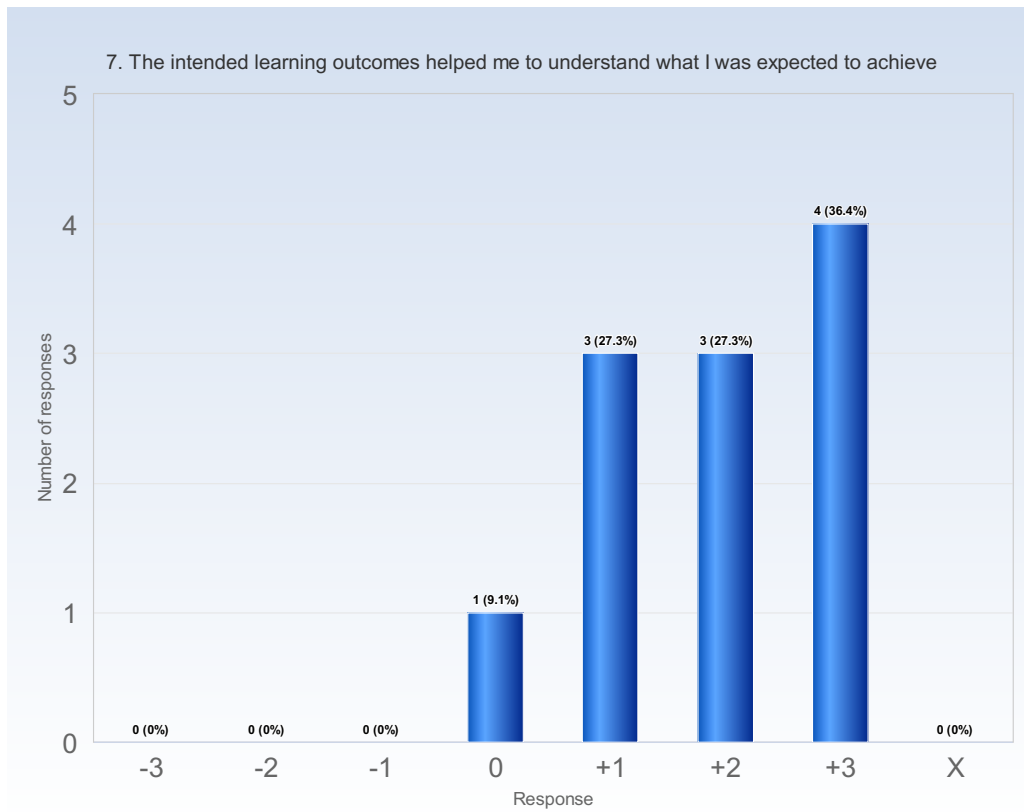
The diagrams below show the detailed response to the LEQ statements. The response scale is defined by:

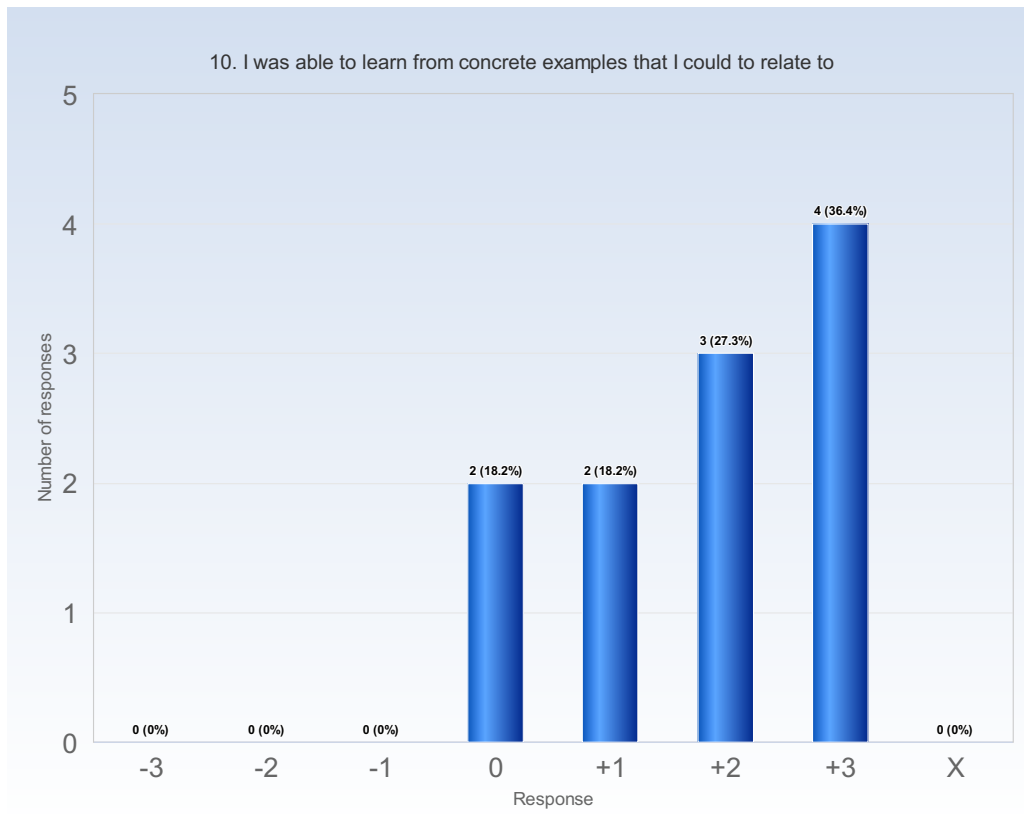
- 3 = No, I strongly disagree with the statement
- 0 = I am neutral to the statement
- +3 = Yes, I strongly agree with the statement

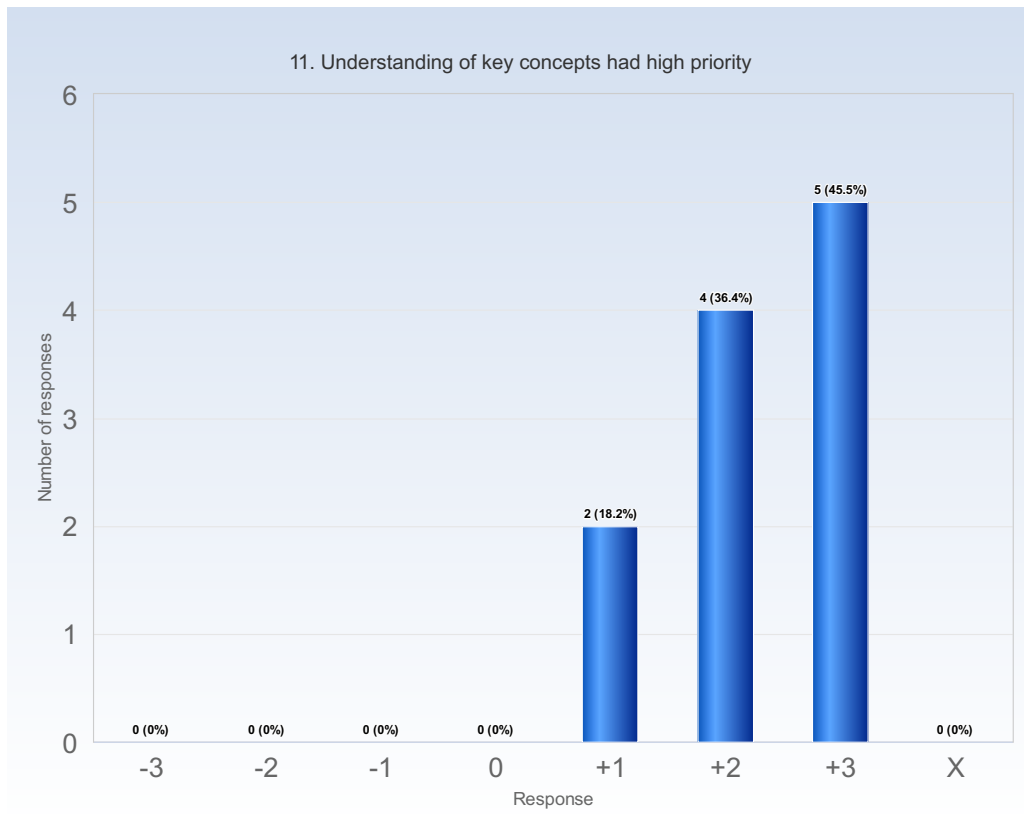
X = I decline to take a position on the statement

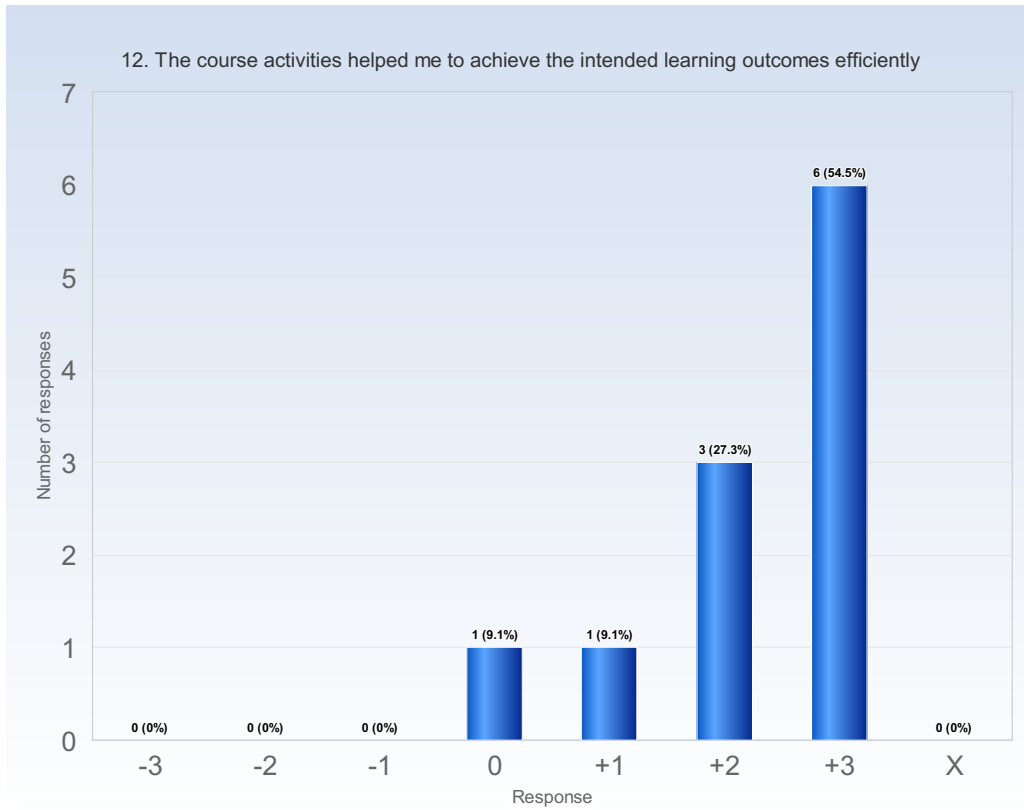


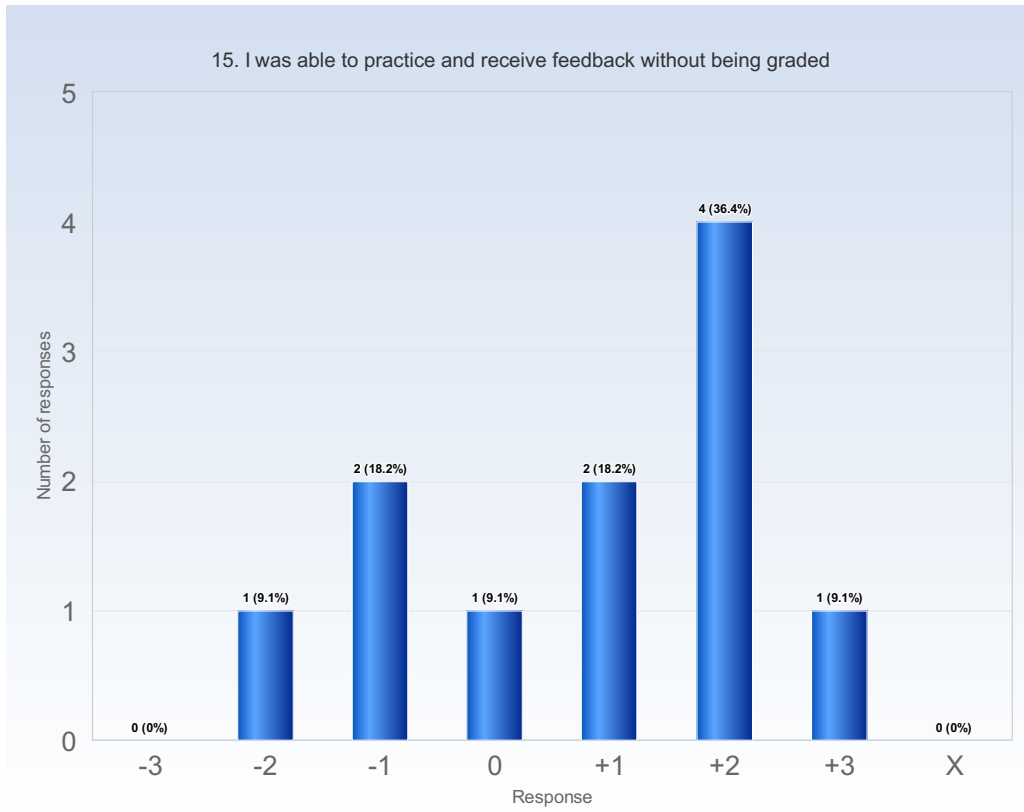


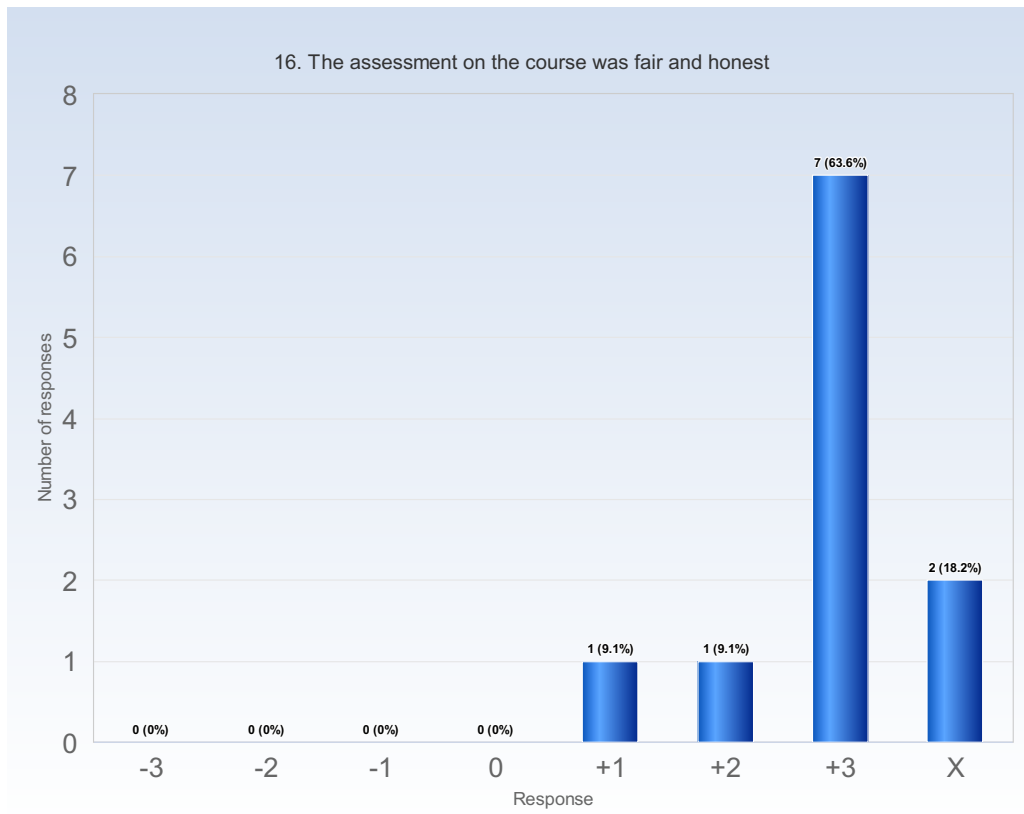


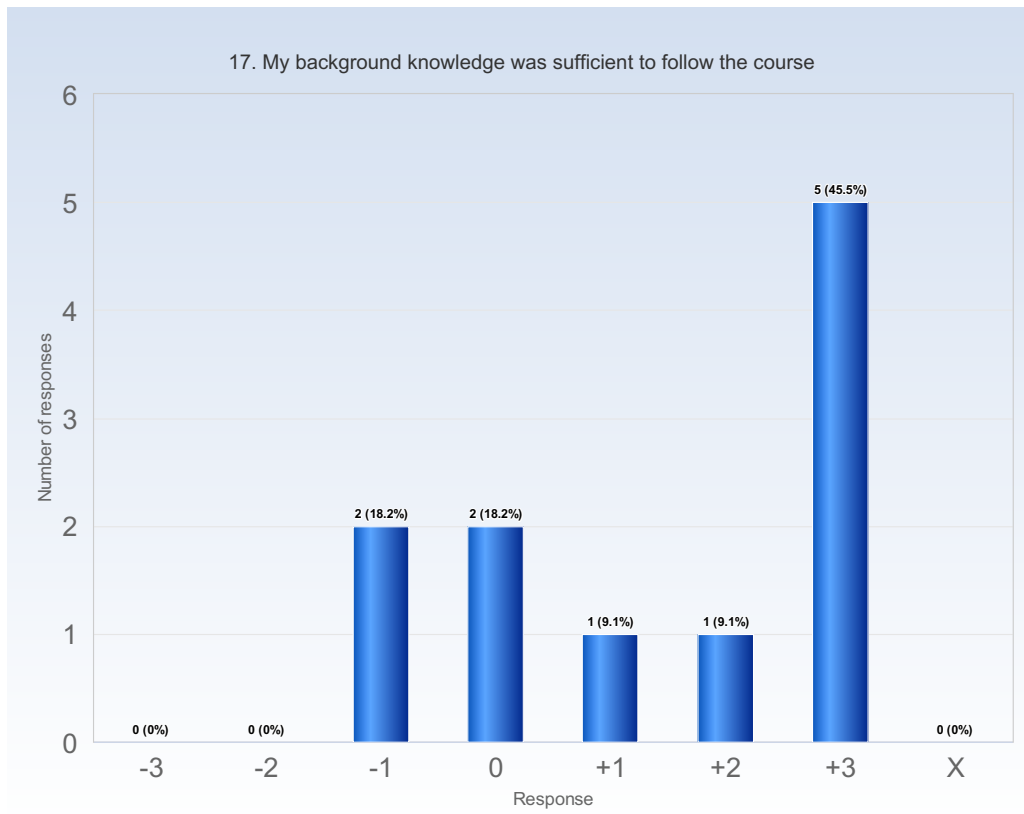


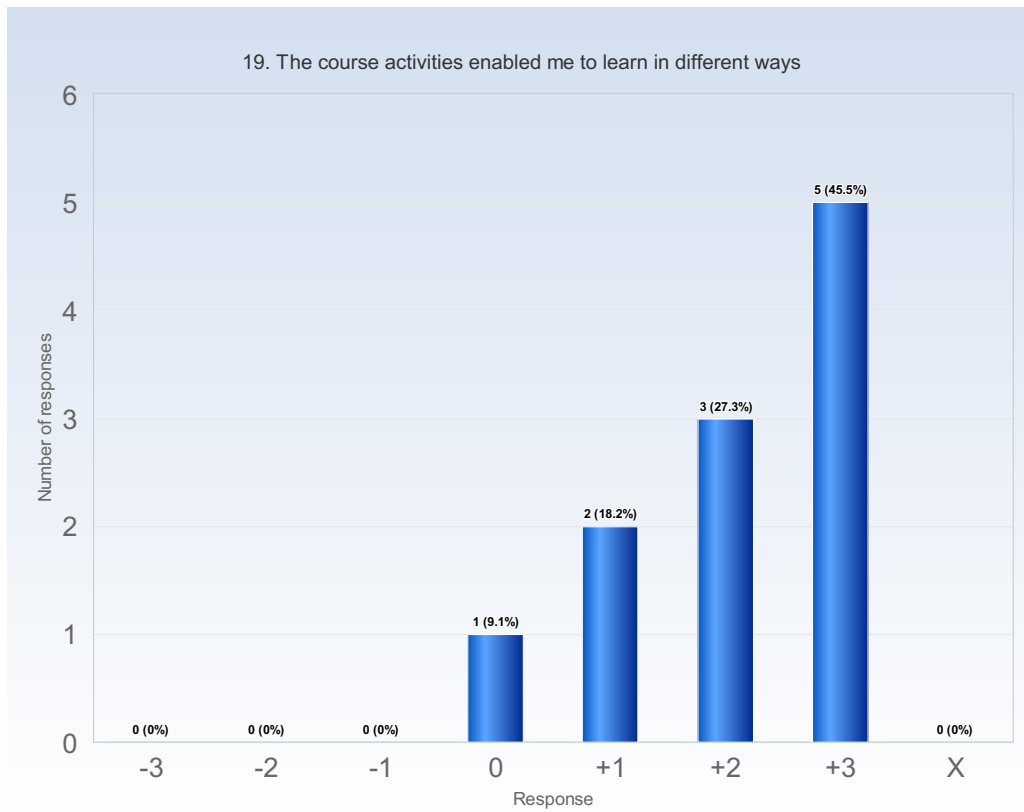


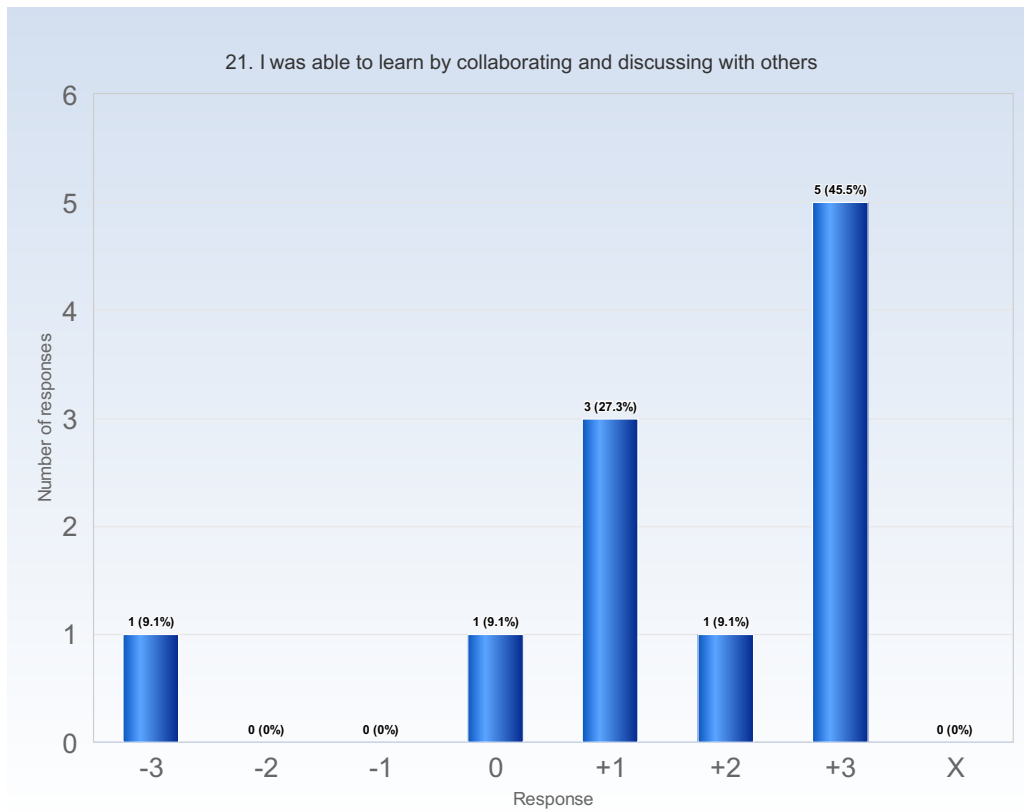












Comments

Comments (My response was: +1)

The homeworks were individual and there were no discussions in class

