# Report - SF2812 - 2018-05-18

Respondents: 1
Answer Count: 1
Answer Frequency: 100.00 %

**Please note that there is only one respondent to this form: the person that performs the course analysis.**

**Course analysis carried out by (name, e-mail):**

Anders Forsgren, andersf@kth.se

**COURSE DESIGN**

**Briefly describe the course design (learning activities, examinations) and any changes that have been implemented since the last course offering.**

The course covers linear and integer programming. The course is based on projects, where students get training in modeling and analysis of practical problems, in addition to lectures and tutorials, where students get understanding of theory and methods.

The project part of the course consisted of two project exercise in the form of modeling exercises, which were modeled in GAMS. Larger problems were successfully solved with the use of NEOS. The projects had parallel exercises, four each for exercises one and two. The group sizes were two or three persons and the groups were selected by me. The projects are presented at a particular lecture. This presentations lecture is devoted to discussion between students. First, students having worked on the same project sat together and discussed. As a second part of the lecture, students having worked on different projects sat together and discussed, three persons in each group. In addition, we have the "follow-up" discussions with the groups after the presentation lectures.

As earlier years I used laptop and project as support for the teaching. This gives a "skeleton" of the course material. The slides are written using LaTeX. By the laptop I could also illustrate some example problems by using GAMS and Matlab.

David Ek was teaching assistant, as last year.

**THE STUDENT'S WORKLOAD**

**Does the students' workload correspond to the expected level (40 hours/1.5 credits)? If there is a significant deviation from the expected, what can be the reason?**

Counting for ten weeks and 7.5 credits would give 20 hours per week. The students report a workload which is less, 12-14 hours a week would be the average. I think that the students think about the projects even when they do not work actively with them, so the workload i slightly higher. A rather large group of students report 6-8 hours per week, which I think is not sufficient, in general.

**THE STUDENTS' RESULTS**

**How well have the students succeeded on the course? If there are significant differences compared to previous course offerings, what can be the reason?**

The results on the exam were not quite up to the standards of previous years. First exam, in March, had 27 pass and 21 failed, out of 48. The second exam, in June, had 13 pass and 7 failed out of 20. This is a trend from last year, which now unfortunately was even stronger.

The setup of the course is such that it suits students who want to take the course. I think this is valid for an advanced master course. It seems, however, that there is a group of students who are not that interested. The course being compulsory for some students is not something I prefer.

**OVERALL IMPRESSION OF THE LEARNING ENVIRONMENT**

**What is your overall impression of the learning environment in the polar diagrams, for example in terms of the students' experience of meaningfulness, comprehensibility and manageability? If there are significant differences between different groups of students, what can be the reason?**

The overall impression of the learning environment is good. This is in line with previous years.

**ANALYSIS OF THE LEARNING ENVIRONMENT**

**Can you identify some stronger or weaker areas of the learning environment in the polar diagram - or in the response to each statement - respectively? Do they have an explanation?**

Collaboration and support get high marks. I think this is due to the setup of the projects and the way we give feedback. Some students are not happy with the way the project groups are set up, since they do not have freedom to choose their group mates. I understand their point of view, but think there is an overall benefit of doing it the way it is done.

**ANSWERS TO OPEN QUESTIONS**

**What emerges in the students' answers to the open questions? Is there any good advice to future course participants that you want to pass on?**

The students are in general happy with the course. It would be helpful for the new students to read the advice given.

**PRIORITY COURSE DEVELOPMENT**

**What aspects of the course should primarily be developed? How could these aspects be developed in the short or long term?**

New projects are always useful. I would also be interested in developing some basic exercises for the students to do prior to the course, such as finding a basis for the nullspace of a matrix.

**OTHER INFORMATION**

**Is there anything else you would like to add?**

I enjoy very much giving this course. In general, I think it works very well. David Ek is a good teaching assistant.

# Course data 2018-09-18

# SF2812 - Applied Linear Optimization, VT 2018 Doktorand

## Course facts

| | |
|---|---|
| **Course start:** | 2018 w.3 |
| **Course end:** | 2018 w.11 |
| **Credits:** | 7,5 |
| **Examination:** | PRO1 - Project, 1.5, Grading scale: A, B, C, D, E, FX, F<br>PRO2 - Project, 1.5, Grading scale: A, B, C, D, E, FX, F<br>TEN1 - Examination, 4.5, Grading scale: A, B, C, D, E, FX, F |
| **Grading scale:** | A, B, C, D, E, FX, F |

## Staff

| | |
|---|---|
| **Examiner:** | Anders Forsgren <andersf@kth.se> |
| **Course responsible teacher:** | Anders Forsgren <andersf@kth.se> |
| **Teachers:** | Anders Forsgren <andersf@kth.se> |
| **Assistants:** | |

## Number of students on the course offering

| | |
|---|---|
| **First-time registered:** | 0 |
| **Total number of registered:** | 19 |

## Achievements (only first-time registered students)

| | |
|---|---|
| **Pass rate[1] [%]** | *There are no course results reported* |
| **Performance rate[2] [%]** | *There are no course results reported* |
| **Grade distribution[3] [%, number]** | *There are no course results reported* |

1 Percentage approved students
2 Percentage achieved credits
3 Distribution of grades among the approved students

# SF2812 - Applied Linear Optimization, VT 2018

## Course facts

| | |
|---|---|
| **Course start:** | 2018 w.3 |
| **Course end:** | 2018 w.11 |
| **Credits:** | 7,5 |
| **Examination:** | PRO1 - Project, 1.5, Grading scale: A, B, C, D, E, FX, F<br>PRO2 - Project, 1.5, Grading scale: A, B, C, D, E, FX, F<br>TEN1 - Examination, 4.5, Grading scale: A, B, C, D, E, FX, F |
| **Grading scale:** | A, B, C, D, E, FX, F |

## Staff

| | |
|---|---|
| **Examiner:** | Anders Forsgren <andersf@kth.se> |
| **Course responsible teacher:** | Anders Forsgren <andersf@kth.se> |
| **Teachers:** | Anders Forsgren <andersf@kth.se> |
| **Assistants:** | David Ek <daviek@kth.se> |

## Number of students on the course offering

| | |
|---|---|
| **First-time registered:** | 45 |
| **Total number of registered:** | 63 |

## Achievements (only first-time registered students)

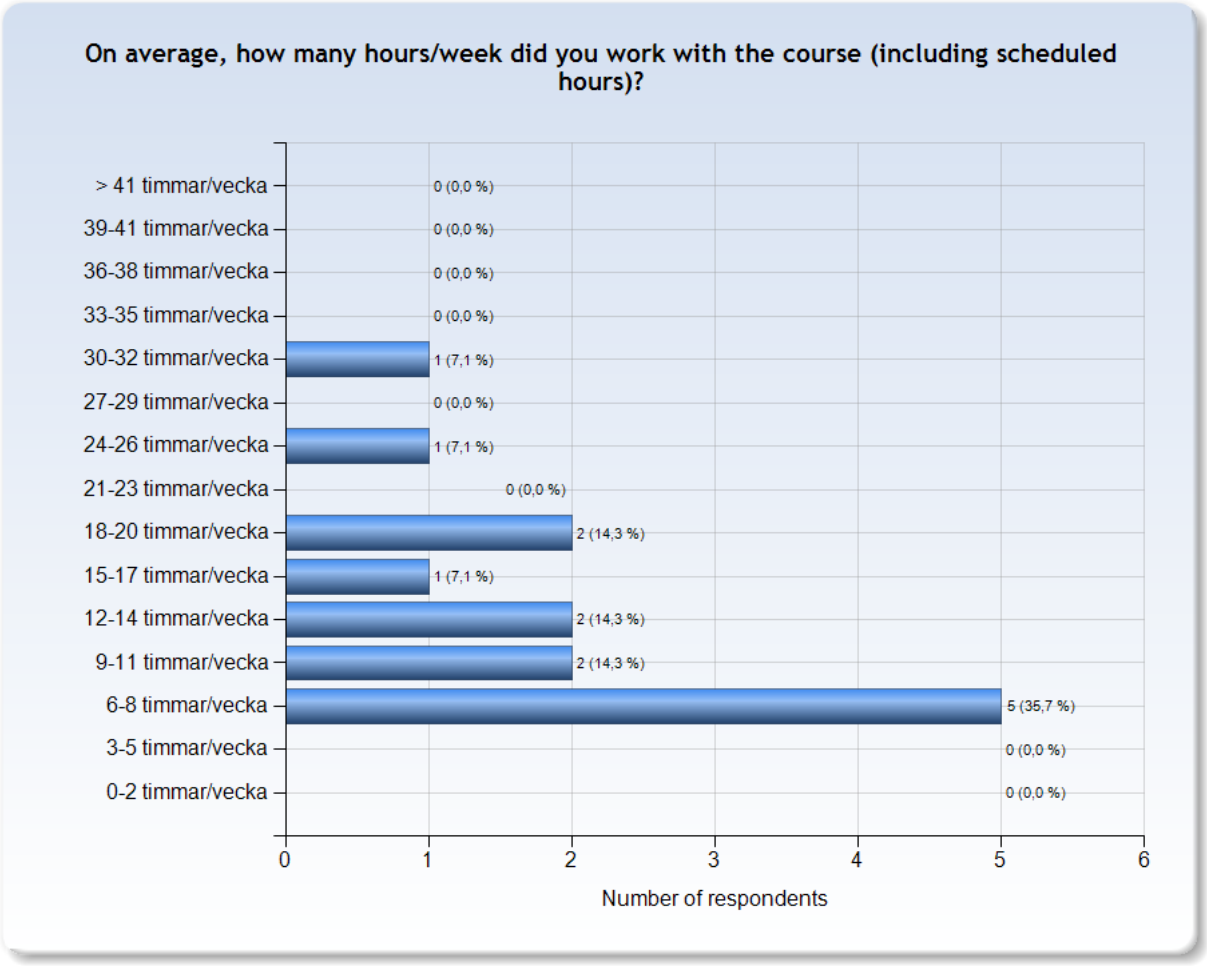
| | |
|---|---|
| **Pass rate[1] [%]** | 64.40% |
| **Performance rate[2] [%]** | 75.60% |
| **Grade distribution[3] [%, number]** | A 21% (6)<br>B 41% (12)<br>C 31% (9)<br>D 7% (2) |

1 Percentage approved students
2 Percentage achieved credits
3 Distribution of grades among the approved students

# SF2812 - 2018-03-14

Antal respondenter: 46
Antal svar: 14
Svarsfrekvens: 30,43 %

# ESTIMATED WORKLOAD




**Comments**

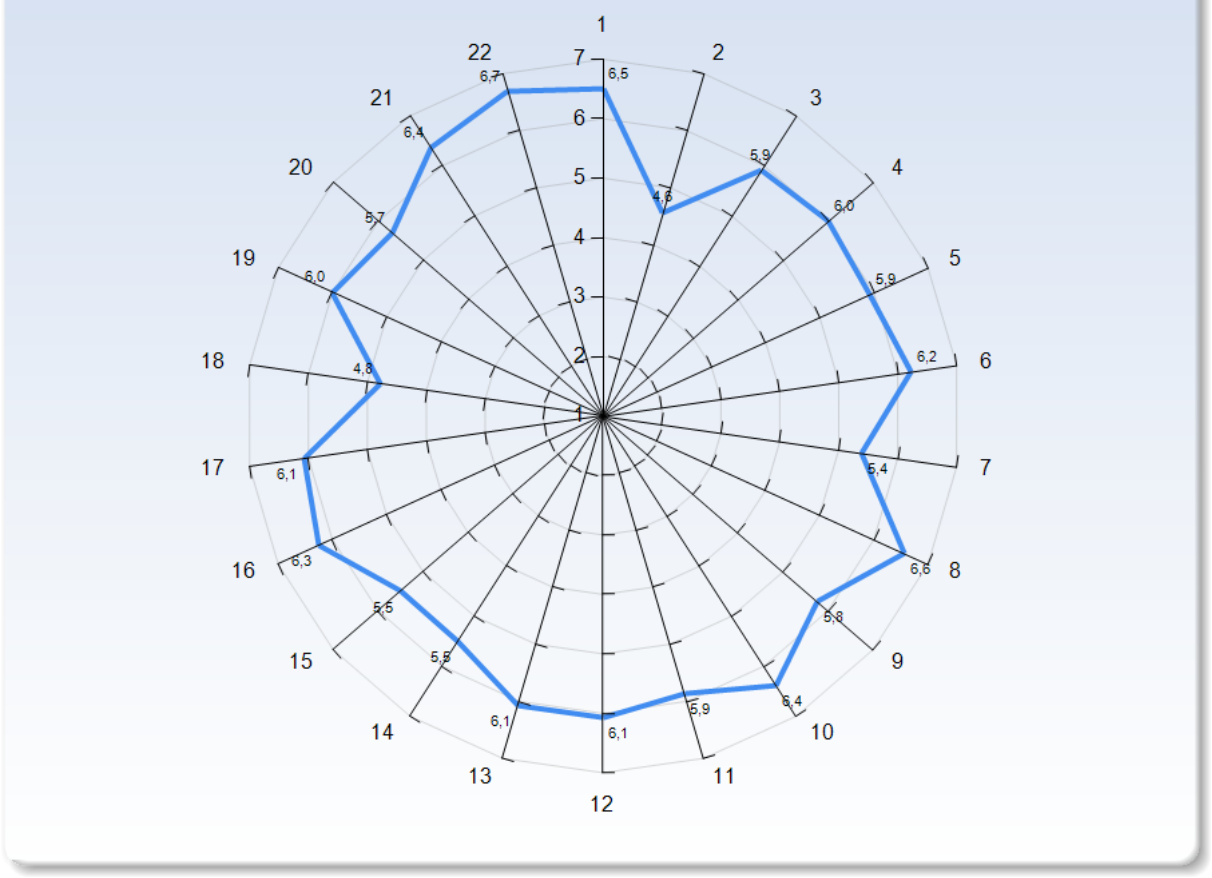
| Comments (I worked: 12-14 timmar/vecka) |
| --- |
| Projekten tog många timmar och ökar därför snittet |

# 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.


Average response to LEQ statements - all respondents
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
1
2
3
4
5
6
7
6,5
5,9
6,0
5,9
6,2
5,4
6,6
5,8
6,4
5,9
6,1
6,1
5,5
5,5
6,3
6,1
4,8
6,0
5,7
6,4
6,7

## KTH Learning Experience Questionnaire v3.1.3

### 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. I understood how the course was organized and what I was expected to do (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 choices*

19. I was able to learn in a way that suited me (m)
20. I had opportunities to choose what to do (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, intriguing or important

b) We can speculate, try out 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 yet supportive environment

d) We feel that we are part of a community and believe that other people have faith 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 sufficient background knowledge to manage the present learning situation

g) We can learn inductively by moving from specific examples and experiences to general principles, rather than the other way around

h) We are challenged to develop a proper understanding of key concepts and successively create a coherent whole of the content

i) We believe that the work we are expected to do will help us to reach the intended learning outcomes

j) We can try, fail, and receive feedback in advance of and separate from any summative judgment of our efforts

k) We believe that our work will be considered fairly and honestly

l) We have sufficient time to learn and devote the time necessary to do so

m) We believe that we are in control of our own learning, not manipulated

n) We can work collaboratively with other learners struggling with the same problems

**Literature**

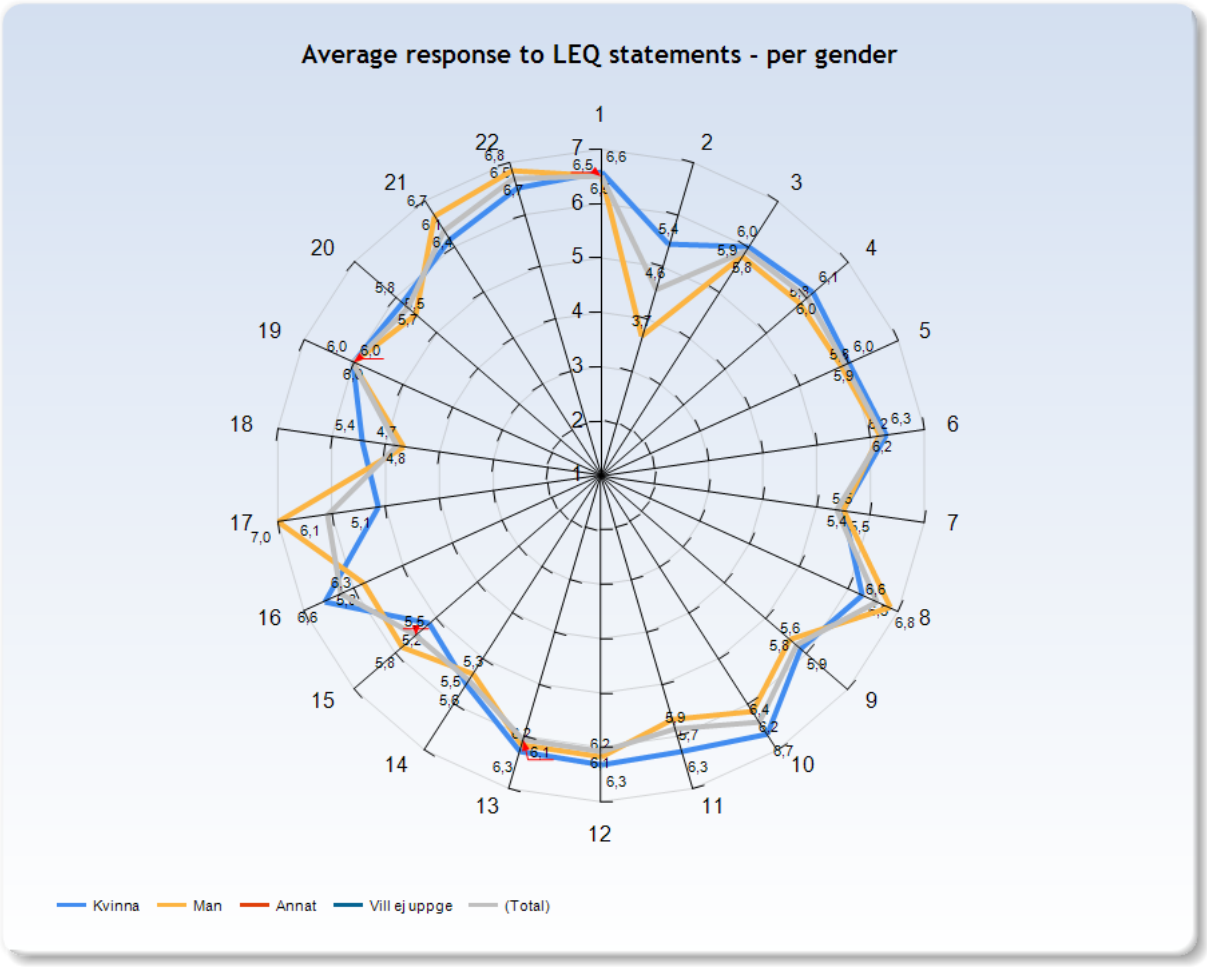
Bain, K. (2004). *What the Best College Teachers Do*, Chapter 5, pp. 98-134. Cambridge: Harvard University Press.

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.

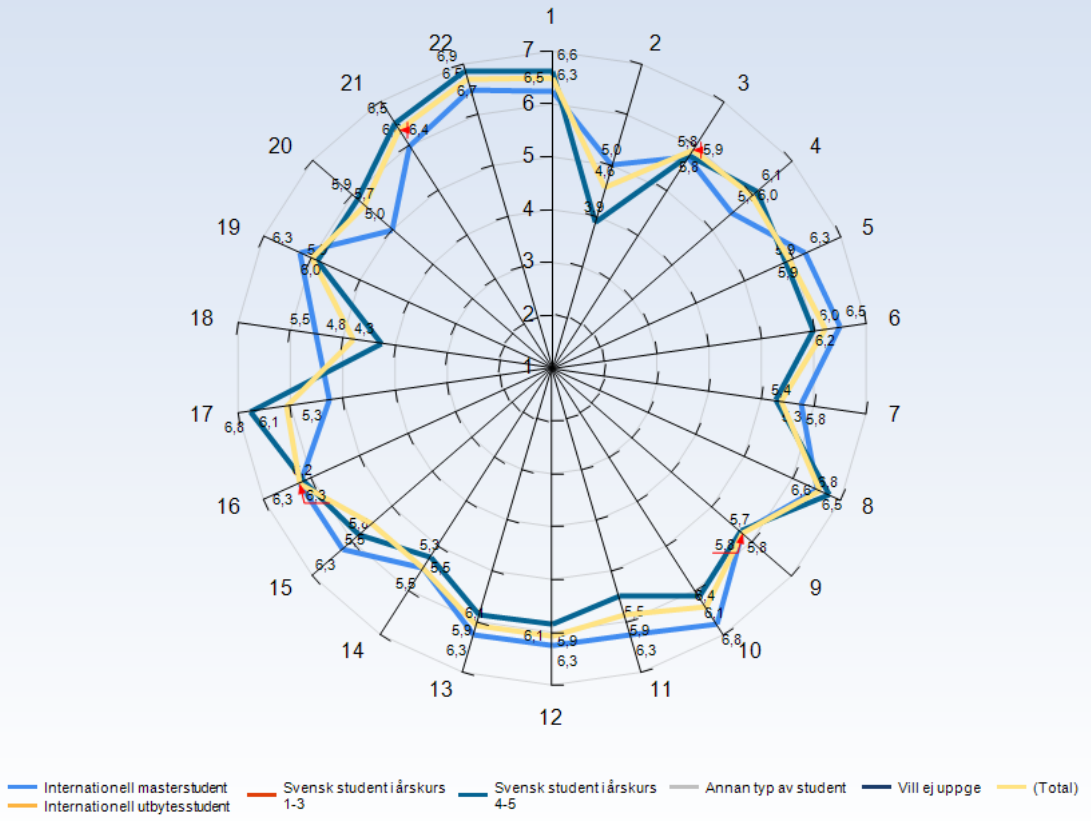
Kember, K. & McNaught, C. (2007). *Enhancing University Teaching: Lessons from Research into Award-Winning Teachers*, Chapter 5, pp. 31-40. Abingdon: Routledge.

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


Average response to LEQ statements - per gender
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
Kvinna
Man
Annat
Vill ej uppge
(Total)

**Comments**

## Average response to LEQ statements - per type of student




**Comments**

# GENERAL QUESTIONS

**What was the best aspect of the course?**

| What was the best aspect of the course? (I worked: 6-8 timmar/vecka) |
|---|
| Learning how to code in GAMS was the best aspect of the course |
| Projects! |
| Structured teacher. I understood what was expected. Also, working with concrete real life problems |

| What was the best aspect of the course? (I worked: 9-11 timmar/vecka) |
|---|
| The best aspect was that there were so many close-to-life examples. The theory was not overwhelming but we still learned at quite a quick pace. Good balance! |
| The projects. |

| What was the best aspect of the course? (I worked: 12-14 timmar/vecka) |
|---|
| Upplägget, och att allt var bestämt (moment, datum, material) redan vid kursstart. |
| The group works |

| What was the best aspect of the course? (I worked: 15-17 timmar/vecka) |
|---|
| Very good projects! Simple and easy to understand but also with relatively practical and realistic data. |

| What was the best aspect of the course? (I worked: 18-20 timmar/vecka) |
|---|
| 1. Both Anders and David (examiner, assistant respectively) was very welcoming when we student's had questions about anything related to the course.<br>2. The structure was very clear and all necessary information was easily received. When all practical things are very clear, it means you can relax as a student and focus on learning. |
| Good teachers and organized course. |

| What was the best aspect of the course? (I worked: 24-26 timmar/vecka) |
|---|
| Really good lecturer and TA |

| What was the best aspect of the course? (I worked: 30-32 timmar/vecka) |
|---|
| The projects |

**What would you suggest to improve?**

| What would you suggest to improve? (I worked: 6-8 timmar/vecka) |
|---|
| Less mathematical theories and more coding |
| Exercise sessions.. to link them more with previous year exam papers. And decrease the speed of exercise sessions. Sometimes its hard to write and follow teacher at the same time . |

| What would you suggest to improve? (I worked: 9-11 timmar/vecka) |
|---|
| Exercise sessions were often a bit rushed, I was barely able to catch up writing it down, let alone think things through and ask many questions. |
| Being able to choose project group. I know it's good to mix and to be able to work with other students, but I think it's more important to have a partner you've chosen by your own, which you can talk to easier and discuss without feeling dumb. |

| What would you suggest to improve? (I worked: 15-17 timmar/vecka) |
|---|
| The oral examination part where one was to talk about the project to people who hadn't done the same one (second hour). Things were just hastily gone through and then the hour was up basically. |

| What would you suggest to improve? (I worked: 18-20 timmar/vecka) |
|---|
| I'm not a big fan of American books in general, way too little substance per written word. I found the proofs in the book unnecessarily messy and not very structured. Unfortunately I have no suggestion for alternative course literature. |

| What would you suggest to improve? (I worked: 24-26 timmar/vecka) |
|---|
| I would rather have lectures without PowerPoints, more of my cup of tea |

| What would you suggest to improve? (I worked: 30-32 timmar/vecka) |
|---|
| People should be divided in who wants to do advanced exercises and who doesn’t and according to this division make the groups. It’s not nice to be the only one or to be only in two working on advanced exercises, when in other groups all the tree people work on them. The time is the same for everyone. Plus maybe a little distinction based on programs should be done as well, because people have too much different background. |

**What advice would you like to give to future participants?**

| What advice would you like to give to future participants? (I worked: 6-8 timmar/vecka) |
|---|
| Make sure that he or she understand how to do simplex method before entering the course |
| To work on theory questions and previous years exams during the term( dont leave it to the end) |

| What advice would you like to give to future participants? (I worked: 12-14 timmar/vecka) |
|---|
| Gör teori-frågorna så tidigt som möjligt |

| What advice would you like to give to future participants? (I worked: 15-17 timmar/vecka) |
|---|
| The projects helped a lot so start with them in good time. Also, read the powerpoint before each lecture in order to follow better during the lecture. |

| What advice would you like to give to future participants? (I worked: 18-20 timmar/vecka) |
|---|
| Attend to all lectures and exercise sessions. Do all preparatory questions and make yourself comfortable with the proofs in an early state of the course. |

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

| What advice would you like to give to future participants? (I worked: 30-32 timmar/vecka) |
|---|
| Study hard from the first week, always do recommended exercises and work hard on the projects. |

**Is there anything else you would like to add?**

| Is there anything else you would like to add? (I worked: 6-8 timmar/vecka) |
|---|
| NA |

| Is there anything else you would like to add? (I worked: 9-11 timmar/vecka) |
|---|
| I did not like that proofs were often incomplete and that that wasn't even mentioned,  I wasn't sure how much detail you would then expect in the exam. |
| No. |

| Is there anything else you would like to add? (I worked: 12-14 timmar/vecka) |
|---|
| Jag gillar att man kan gå in i dem fortsatta kursen nu och veta hur upplägget är, vad som förväntas etc. Toppen att alla föreläsningar ligger uppe osv. Bra strukturerat!! |
| Send the survey after you have corrected the exams. This is a crucial part of the course |

| Is there anything else you would like to add? (I worked: 15-17 timmar/vecka) |
|---|
| Fun and well planned course! |

| Is there anything else you would like to add? (I worked: 18-20 timmar/vecka) |
|---|
| The most interesting and well structured course I've read in a long time at KTH. Thank you. |

| Is there anything else you would like to add? (I worked: 24-26 timmar/vecka) |
|---|
| No |

| Is there anything else you would like to add? (I worked: 30-32 timmar/vecka) |
|---|
| As said, group making should be improved. |

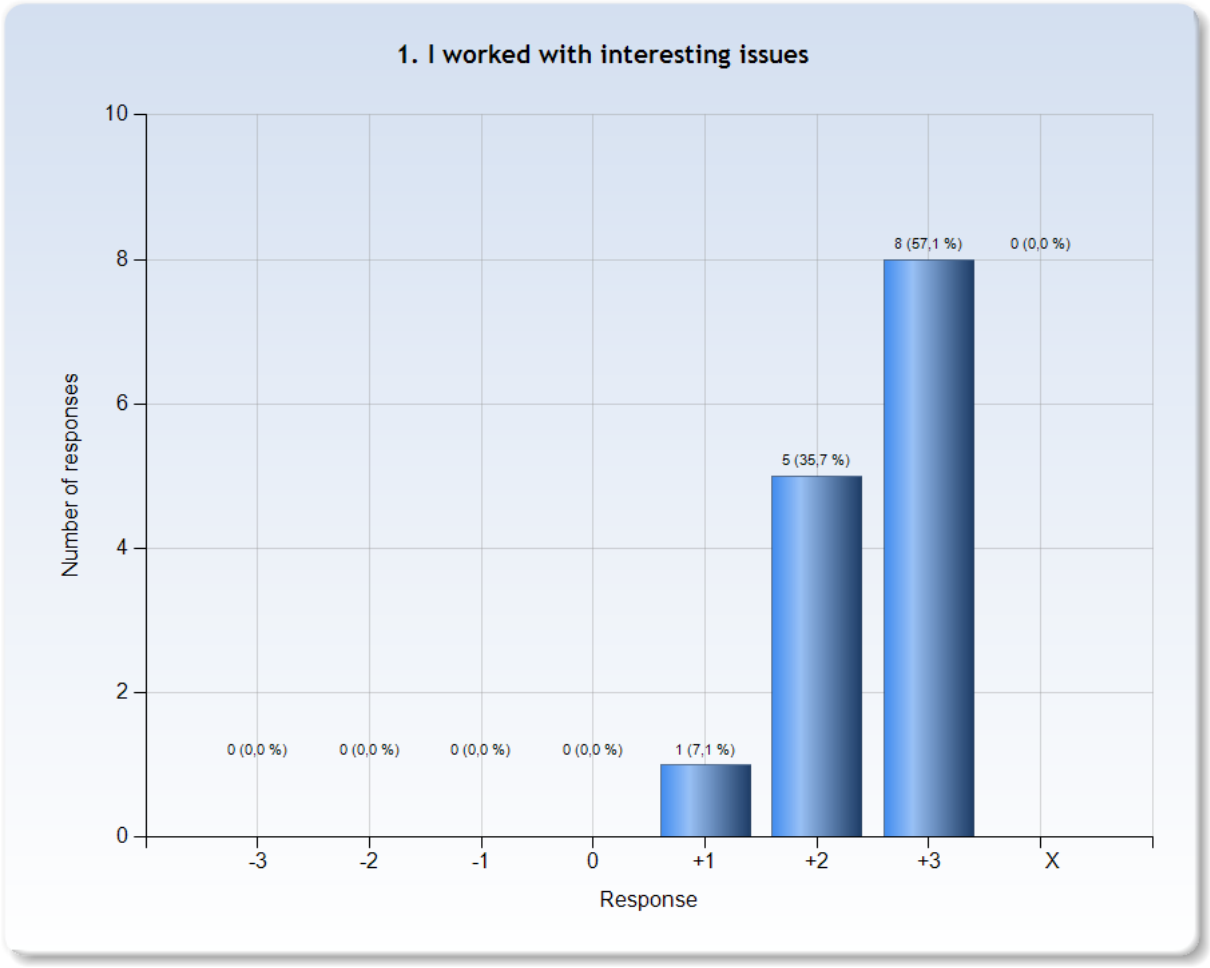
# SPECIFIC QUESTIONS

# RESPONSE DATA

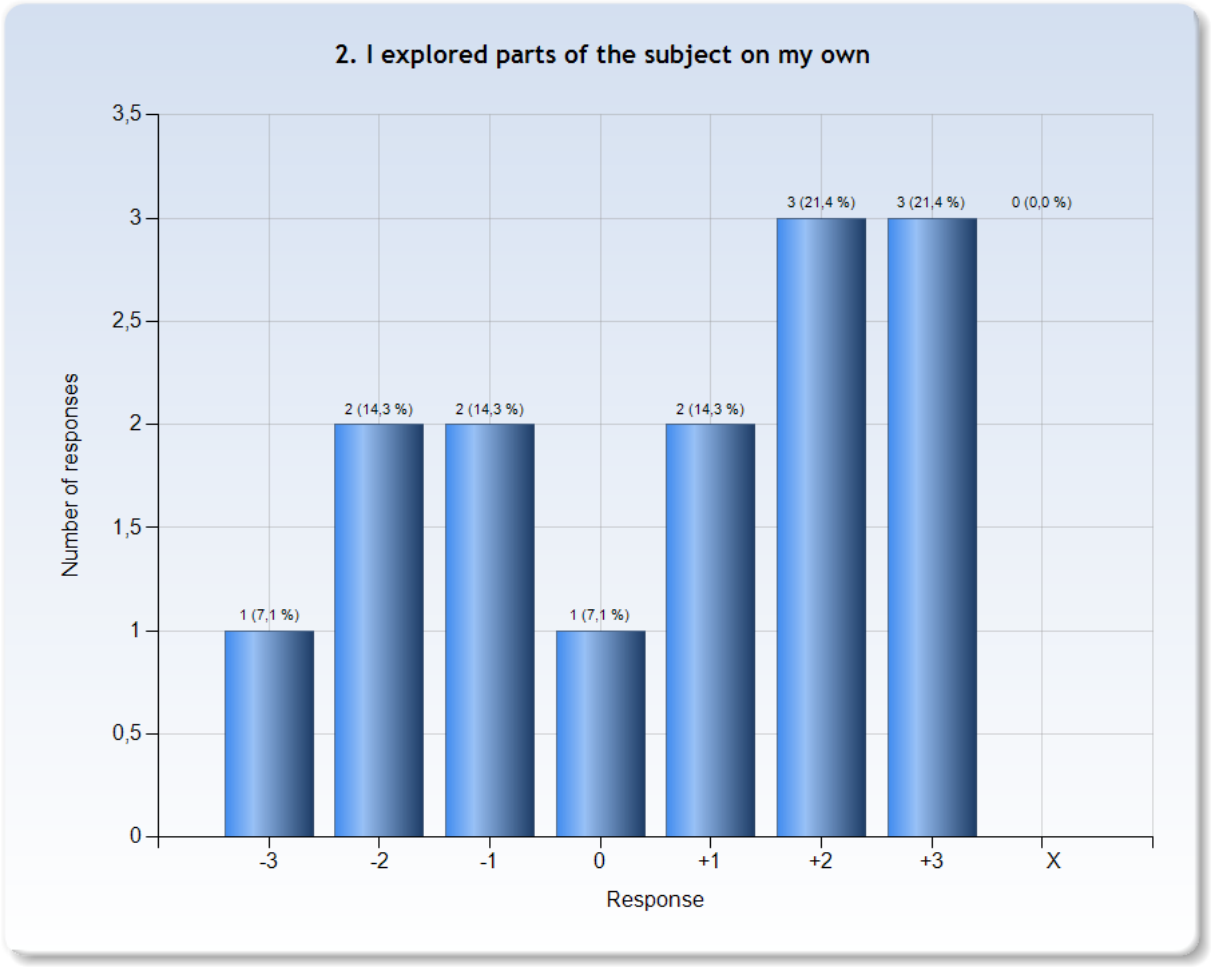
The diagrams below show the detailed response to the LEQ statements. The response scale is defined by:

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

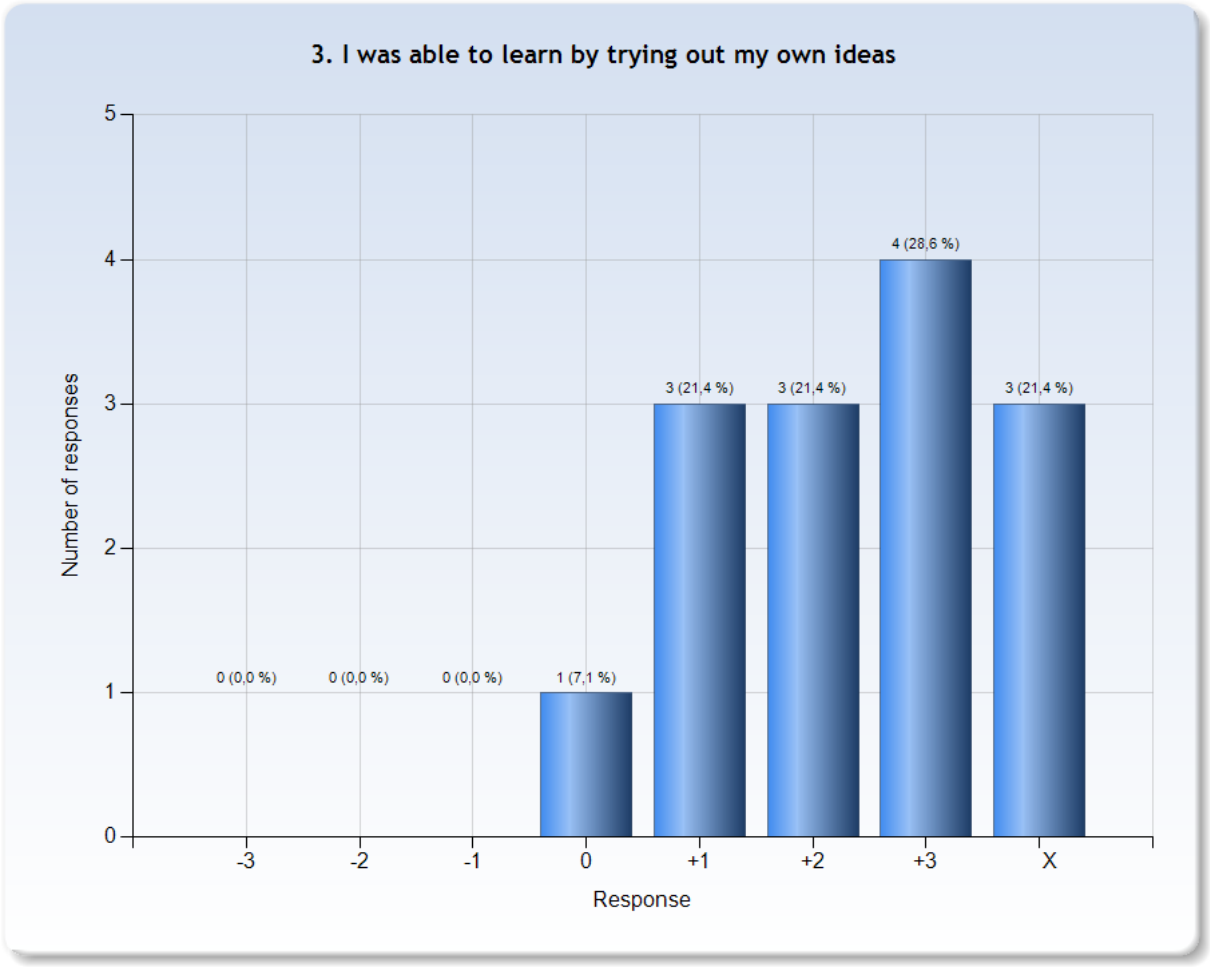
X = I decline to take a position on the statement


1. I worked with interesting issues
10
8
6
4
2
0
Number of responses
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
1 (7,1 %)
5 (35,7 %)
8 (57,1 %)
0 (0,0 %)
-3
-2
-1
0
+1
+2
+3
X
Response

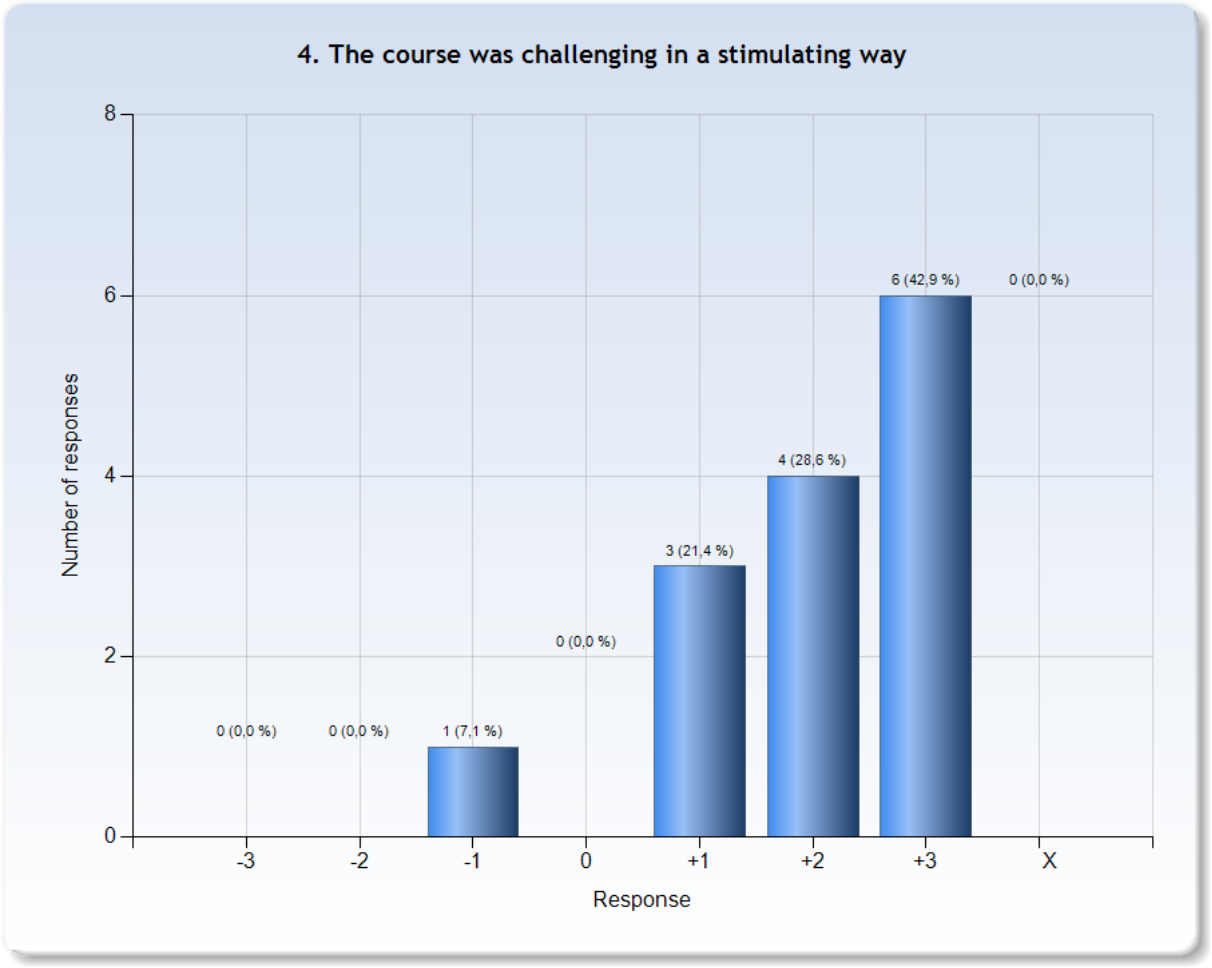
**Comments**


2. I explored parts of the subject on my own
Number of responses
3,5
3
2,5
2
1,5
1
0,5
0
1 (7,1 %)
2 (14,3 %)
2 (14,3 %)
1 (7,1 %)
2 (14,3 %)
3 (21,4 %)
3 (21,4 %)
0 (0,0 %)
-3
-2
-1
0
+1
+2
+3
X
Response

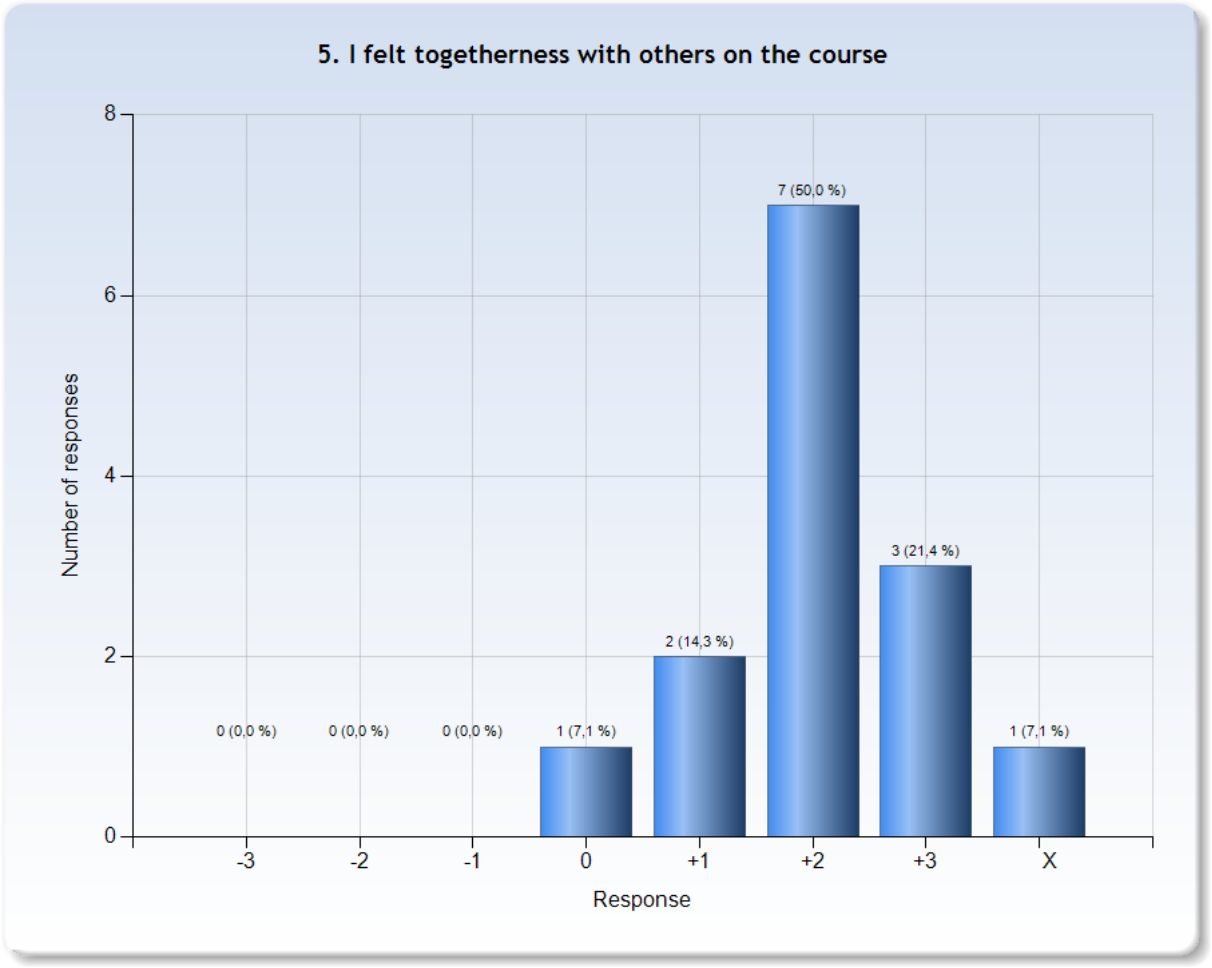
**Comments**


3. I was able to learn by trying out my own ideas
Number of responses
Response
0
1
2
3
4
5
-3
-2
-1
0
+1
+2
+3
X
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
1 (7,1 %)
3 (21,4 %)
3 (21,4 %)
4 (28,6 %)
3 (21,4 %)

**Comments**


4. The course was challenging in a stimulating way
Number of responses
Response
0
2
4
6
8
-3
-2
-1
0
+1
+2
+3
X
0 (0,0 %)
0 (0,0 %)
1 (7,1 %)
0 (0,0 %)
3 (21,4 %)
4 (28,6 %)
6 (42,9 %)
0 (0,0 %)

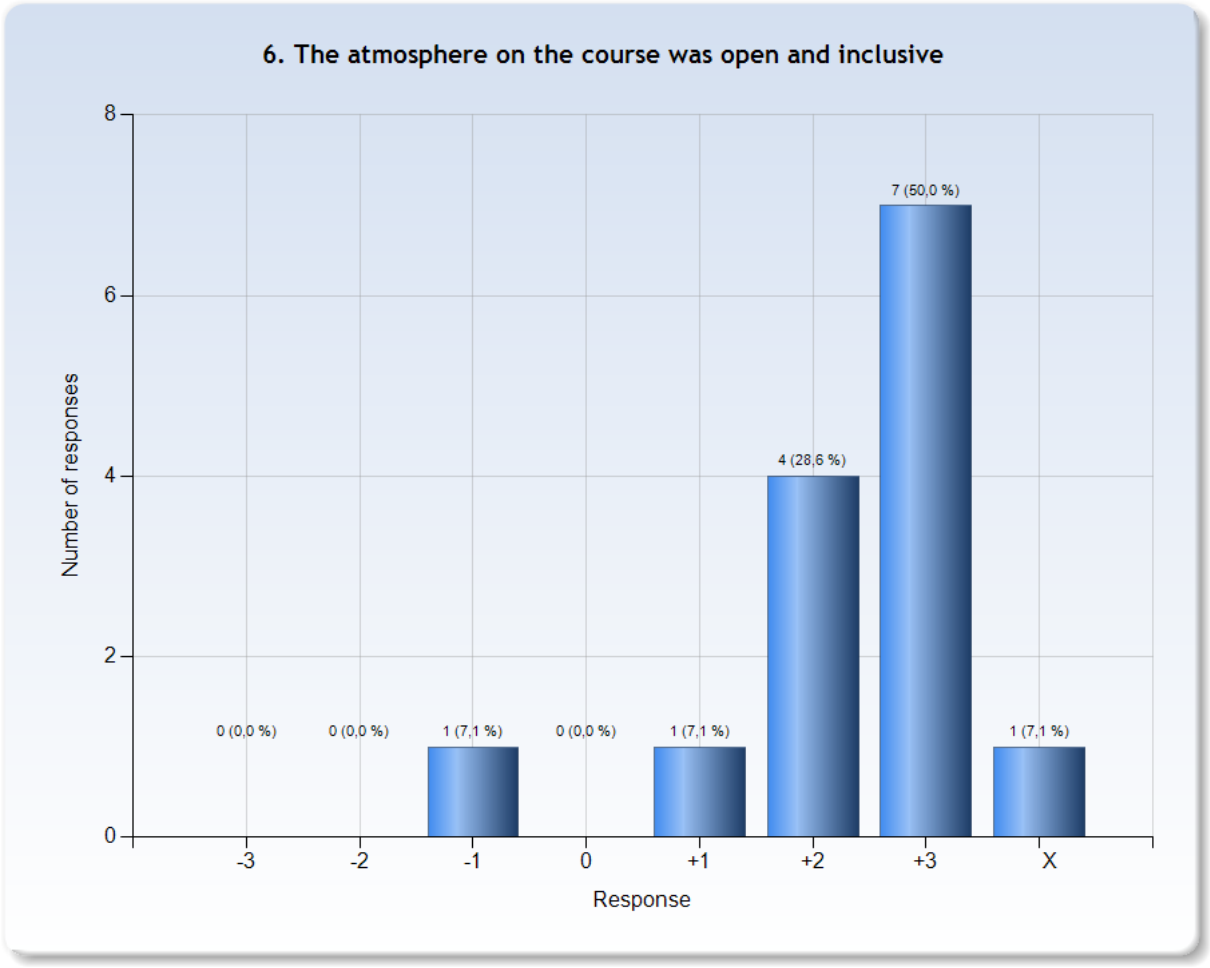
**Comments**




**Comments**

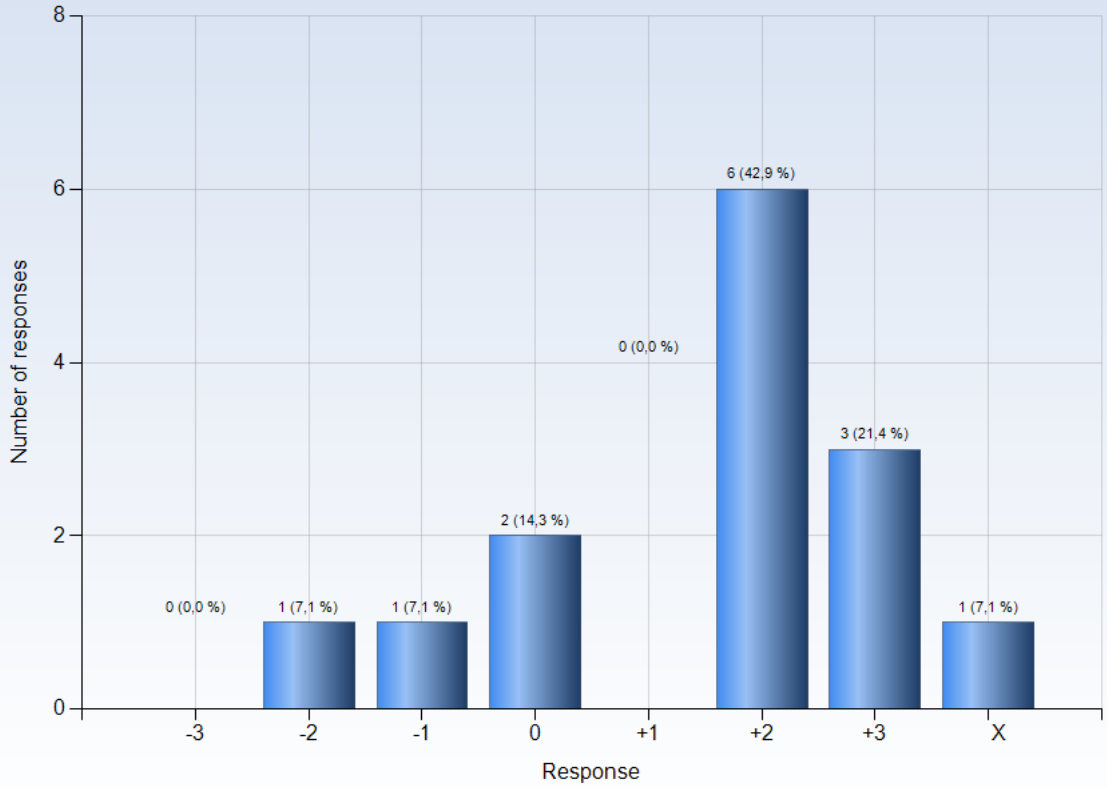
| Comments (My response was: +2) |
|---|
| More than other courses in general |
| Efter gruppdiskussionerna ökade gemenskapen |

| Comments (My response was: X ) |
|---|
| What kind of question is this, it's not kindergarten |

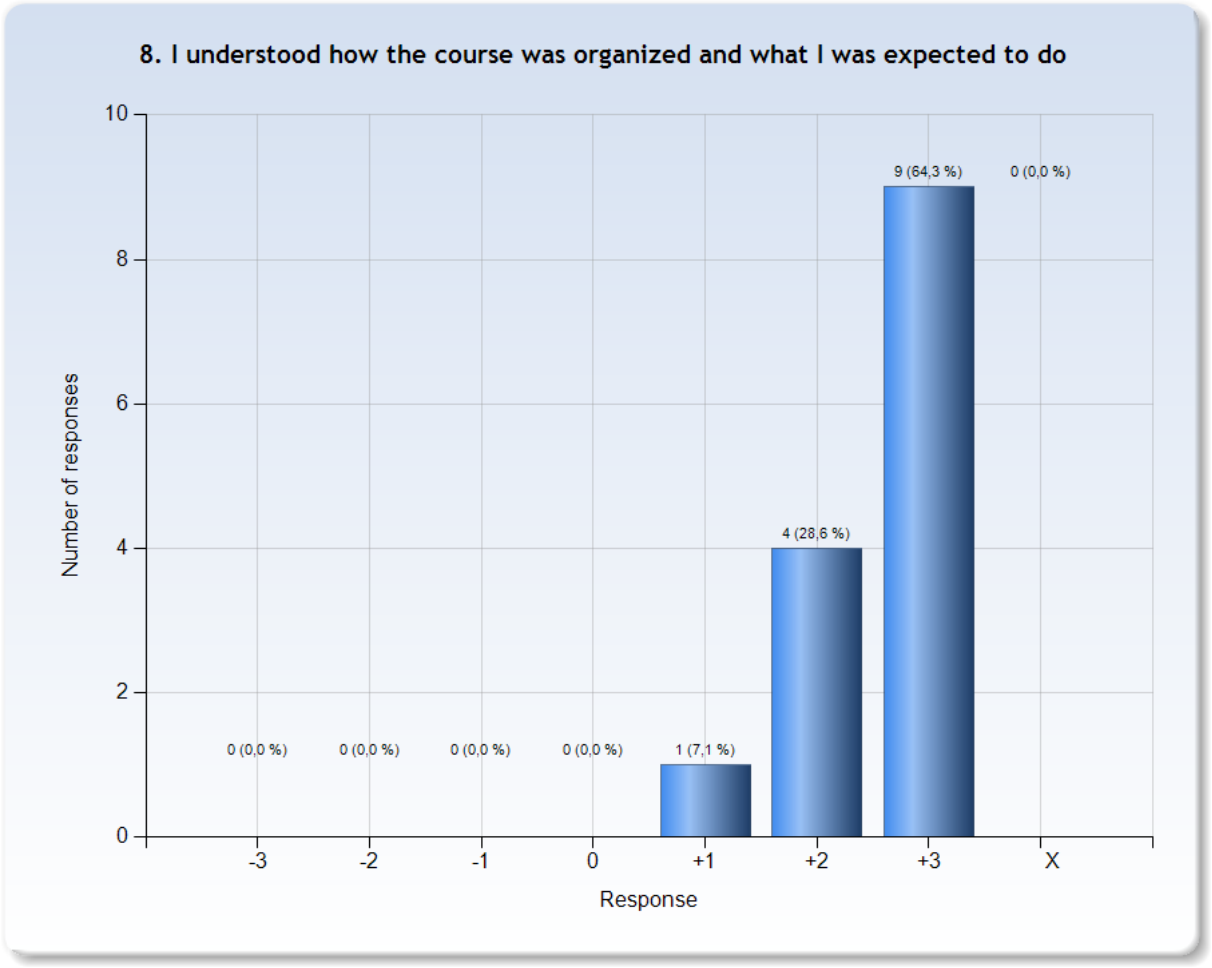

6. The atmosphere on the course was open and inclusive
Number of responses
Response
0
2
4
6
8
-3
-2
-1
0
+1
+2
+3
X
0 (0,0 %)
0 (0,0 %)
1 (7,1 %)
0 (0,0 %)
1 (7,1 %)
4 (28,6 %)
7 (50,0 %)
1 (7,1 %)

**Comments**

## 7. The intended learning outcomes helped me to understand what I was expected to achieve

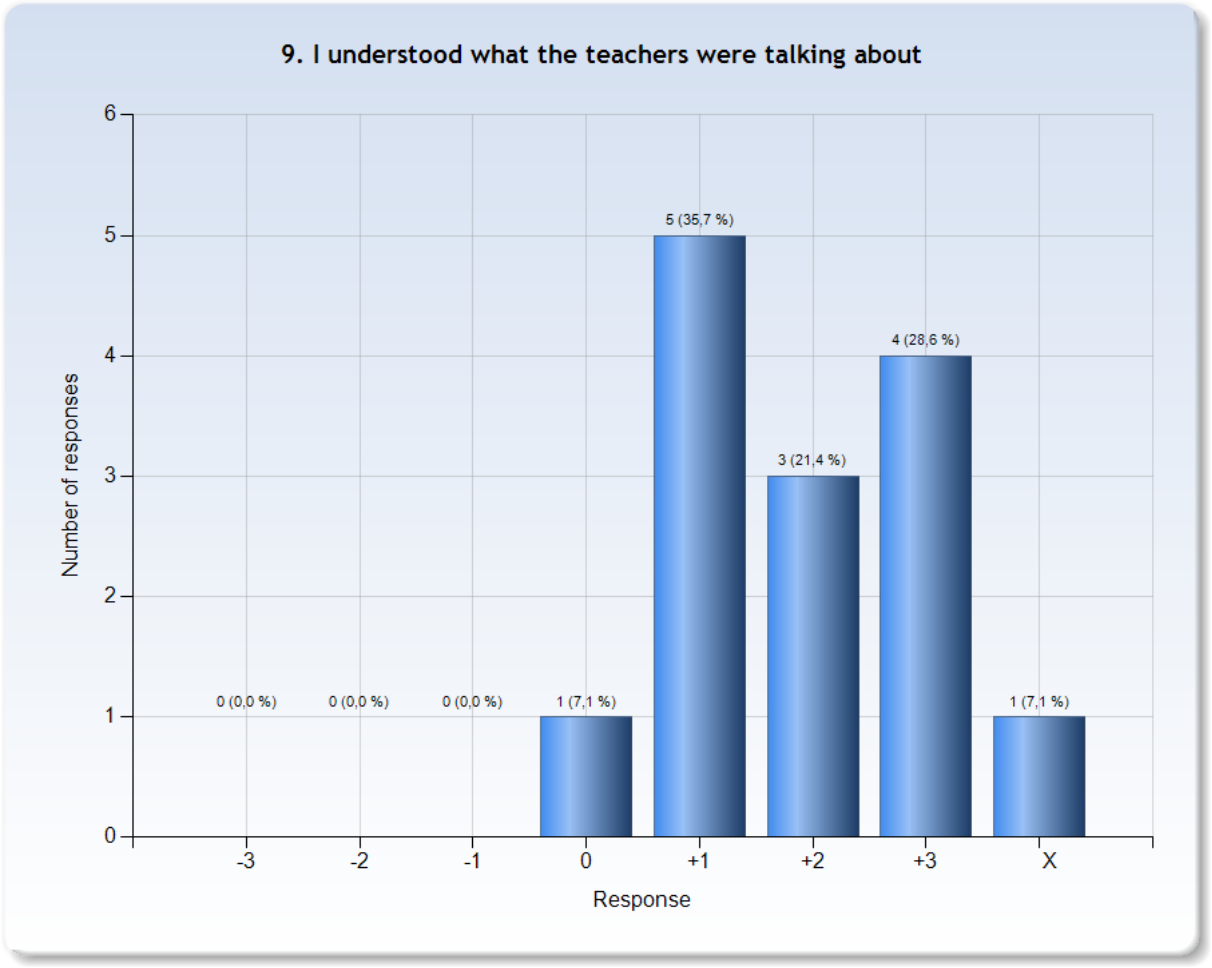



**Comments**



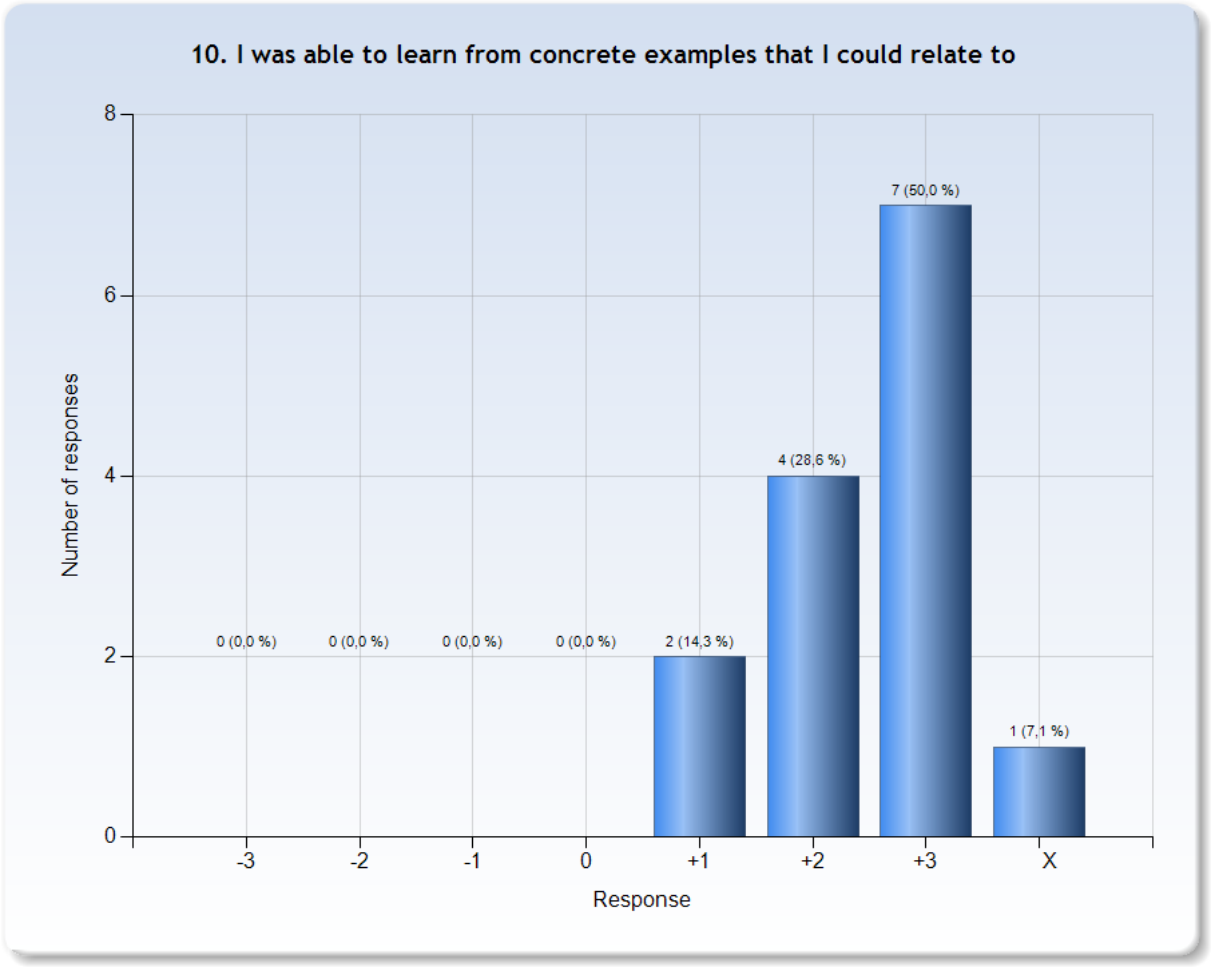

**Comments**

| Comments (My response was: +2) |
| --- |
| Almost always. Except before the first presentation. It would have been helpful if it was explained in more detail what exactly was expected during the presentation session - I hadn't expected it to just be a friendly discussion but expected to have to stand there and hold a mini lecture. It turned out to be much more relaxed and I liked that version better, but that would have been nice to know beforehand. |

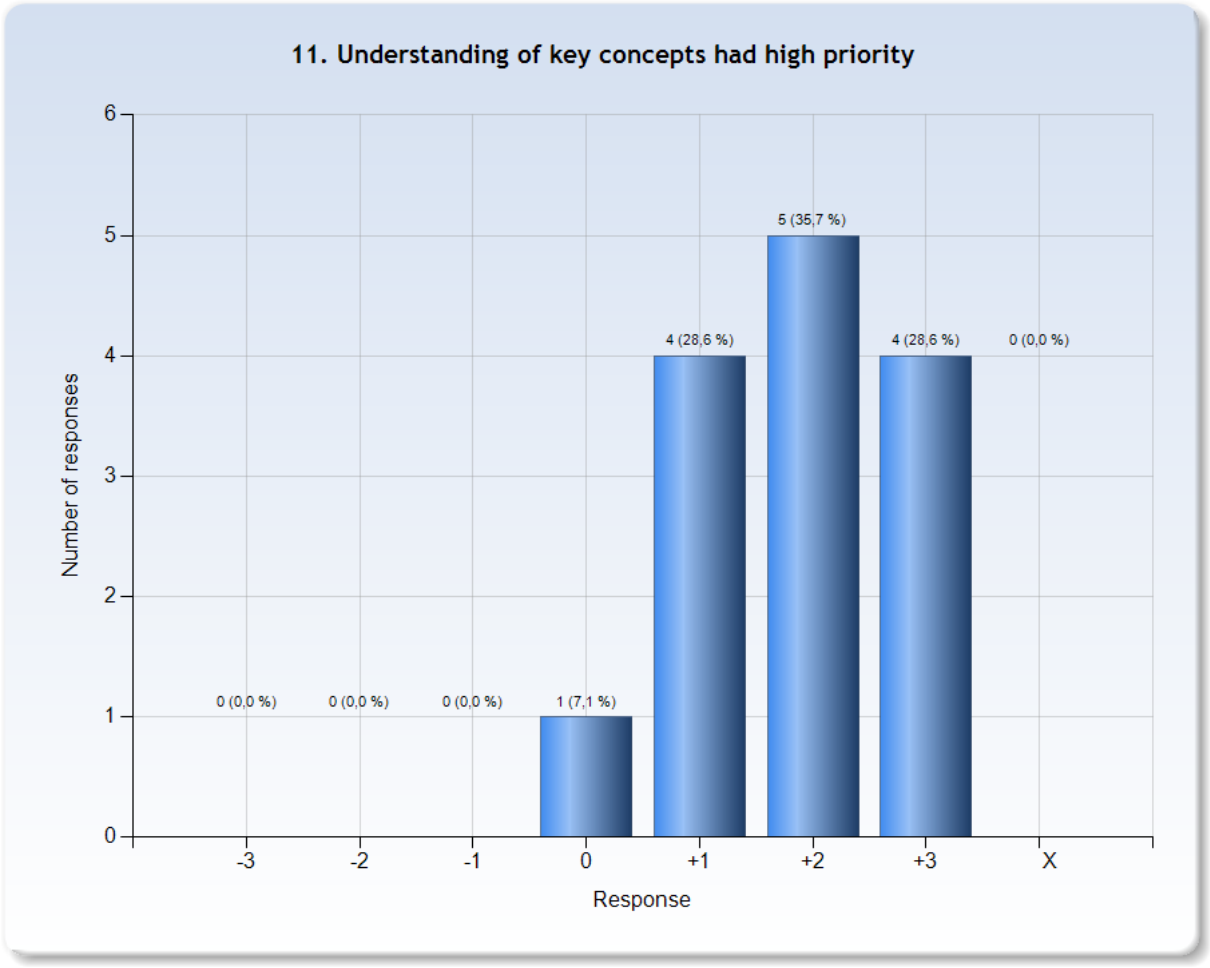



**Comments**

| Comments (My response was: +1) |
| --- |
| Due to lack of preparation before lectures from my side |

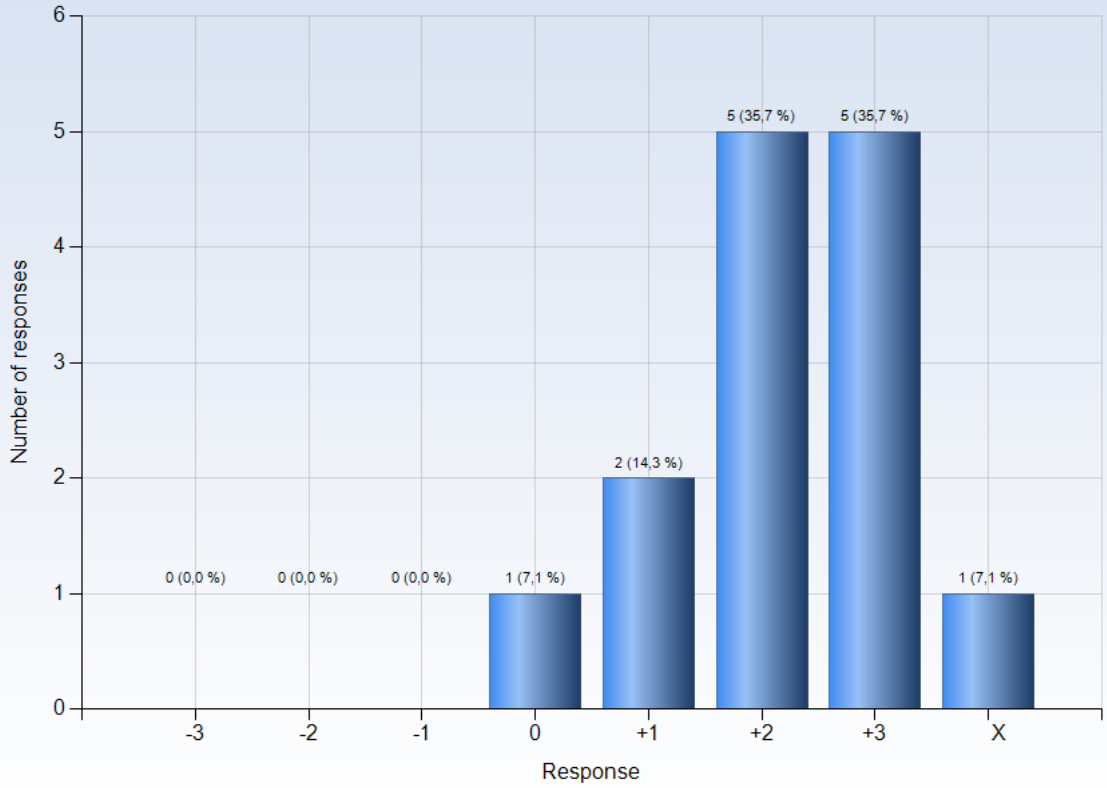

10. I was able to learn from concrete examples that I could relate to
Number of responses
8
6
4
2
0
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
2 (14,3 %)
4 (28,6 %)
7 (50,0 %)
1 (7,1 %)
-3
-2
-1
0
+1
+2
+3
X
Response

**Comments**

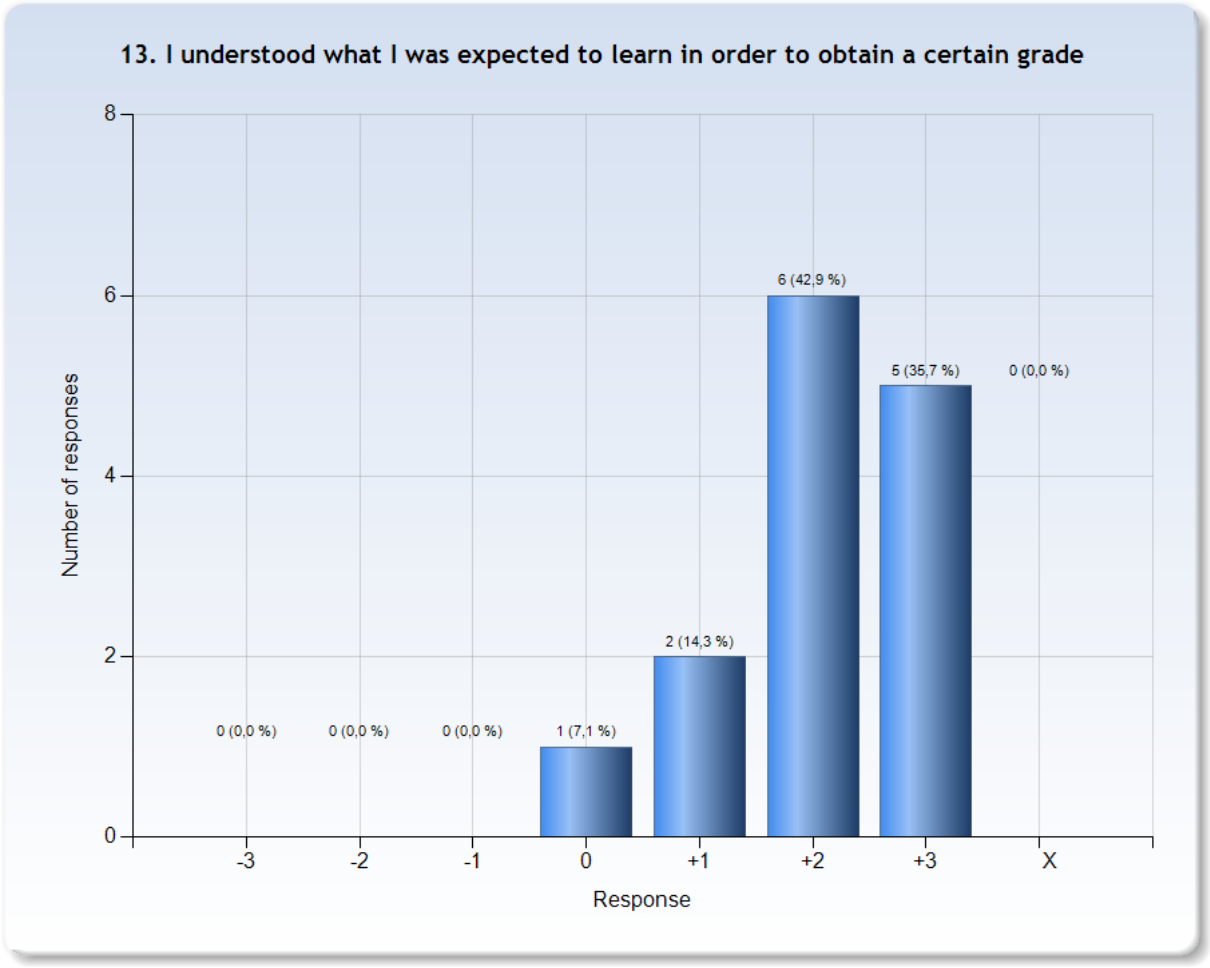

11. Understanding of key concepts had high priority
Number of responses
Response
0
1
2
3
4
5
6
-3
-2
-1
0
+1
+2
+3
X
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
1 (7,1 %)
4 (28,6 %)
5 (35,7 %)
4 (28,6 %)
0 (0,0 %)

**Comments**

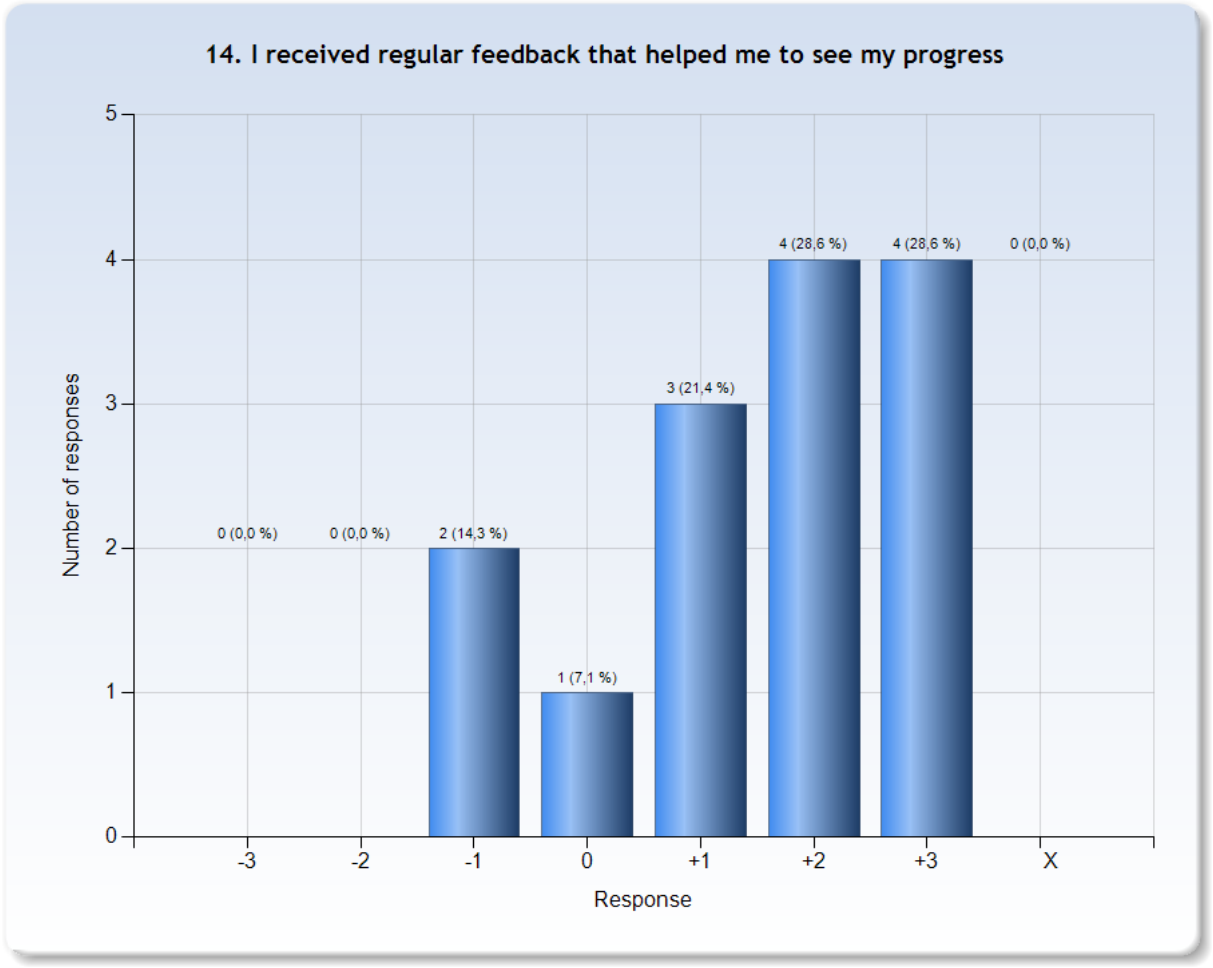
## 12. The course activities helped me to achieve the intended learning outcomes efficiently



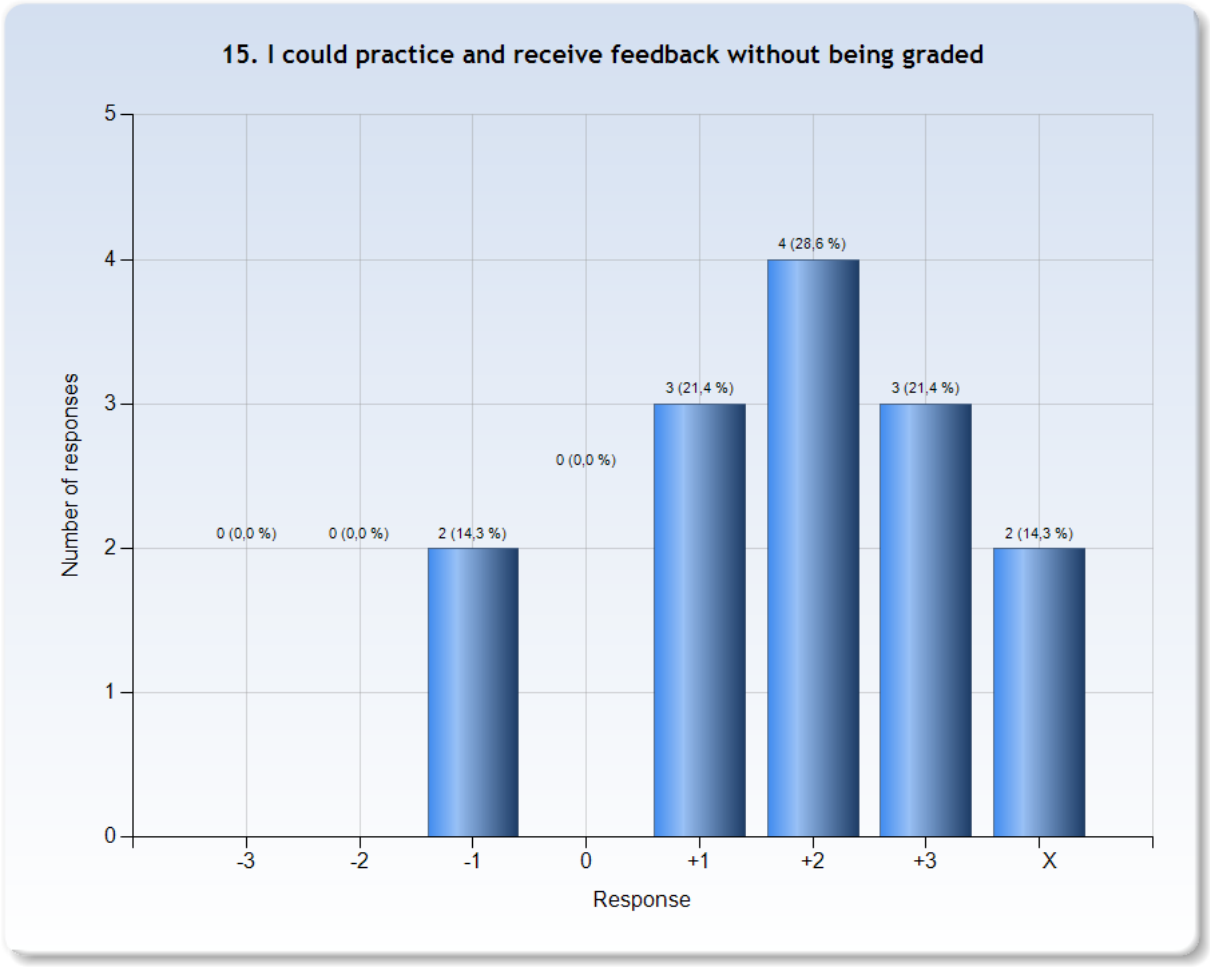

**Comments**


13. I understood what I was expected to learn in order to obtain a certain grade
Number of responses
Response
0
2
4
6
8
-3
-2
-1
0
+1
+2
+3
X
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
1 (7,1 %)
2 (14,3 %)
6 (42,9 %)
5 (35,7 %)
0 (0,0 %)

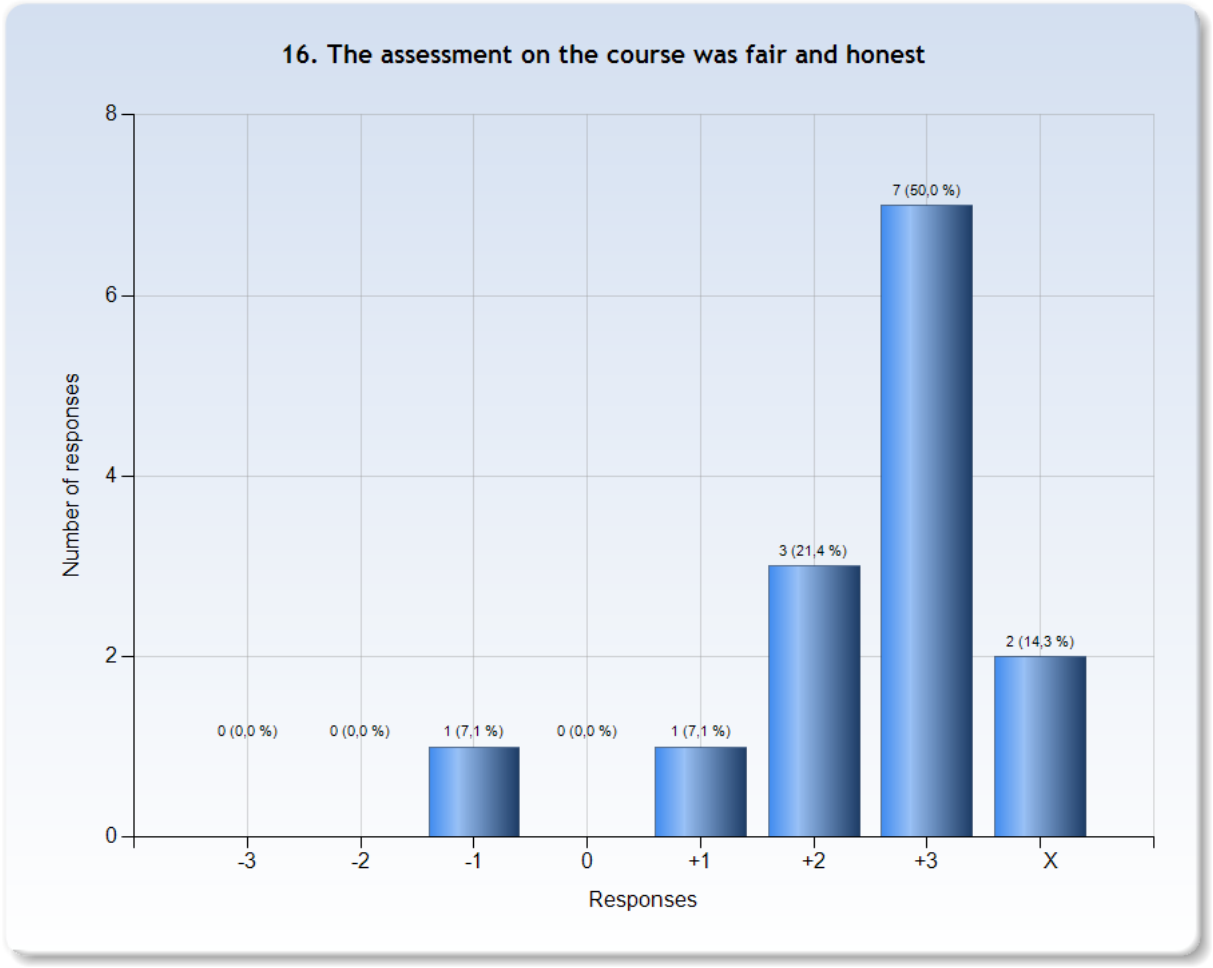
**Comments**


14. I received regular feedback that helped me to see my progress
Number of responses
Response
0 (0,0 %)
0 (0,0 %)
2 (14,3 %)
1 (7,1 %)
3 (21,4 %)
4 (28,6 %)
4 (28,6 %)
0 (0,0 %)
-3
-2
-1
0
+1
+2
+3
X

**Comments**


15. I could practice and receive feedback without being graded
Number of responses
Response
0
1
2
3
4
5
-3
-2
-1
0
+1
+2
+3
X
0 (0,0 %)
0 (0,0 %)
2 (14,3 %)
0 (0,0 %)
3 (21,4 %)
4 (28,6 %)
3 (21,4 %)
2 (14,3 %)

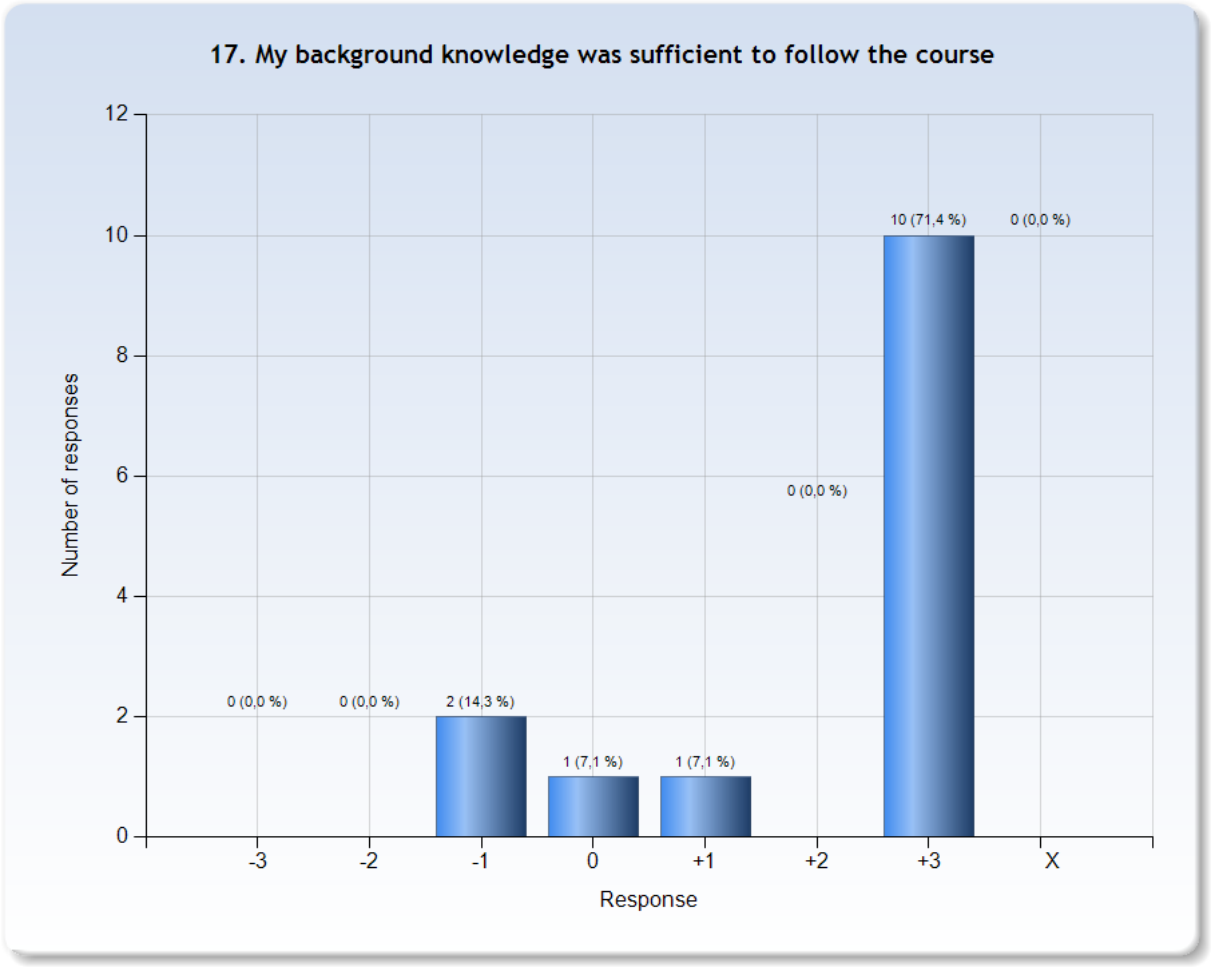
**Comments**




**Comments**

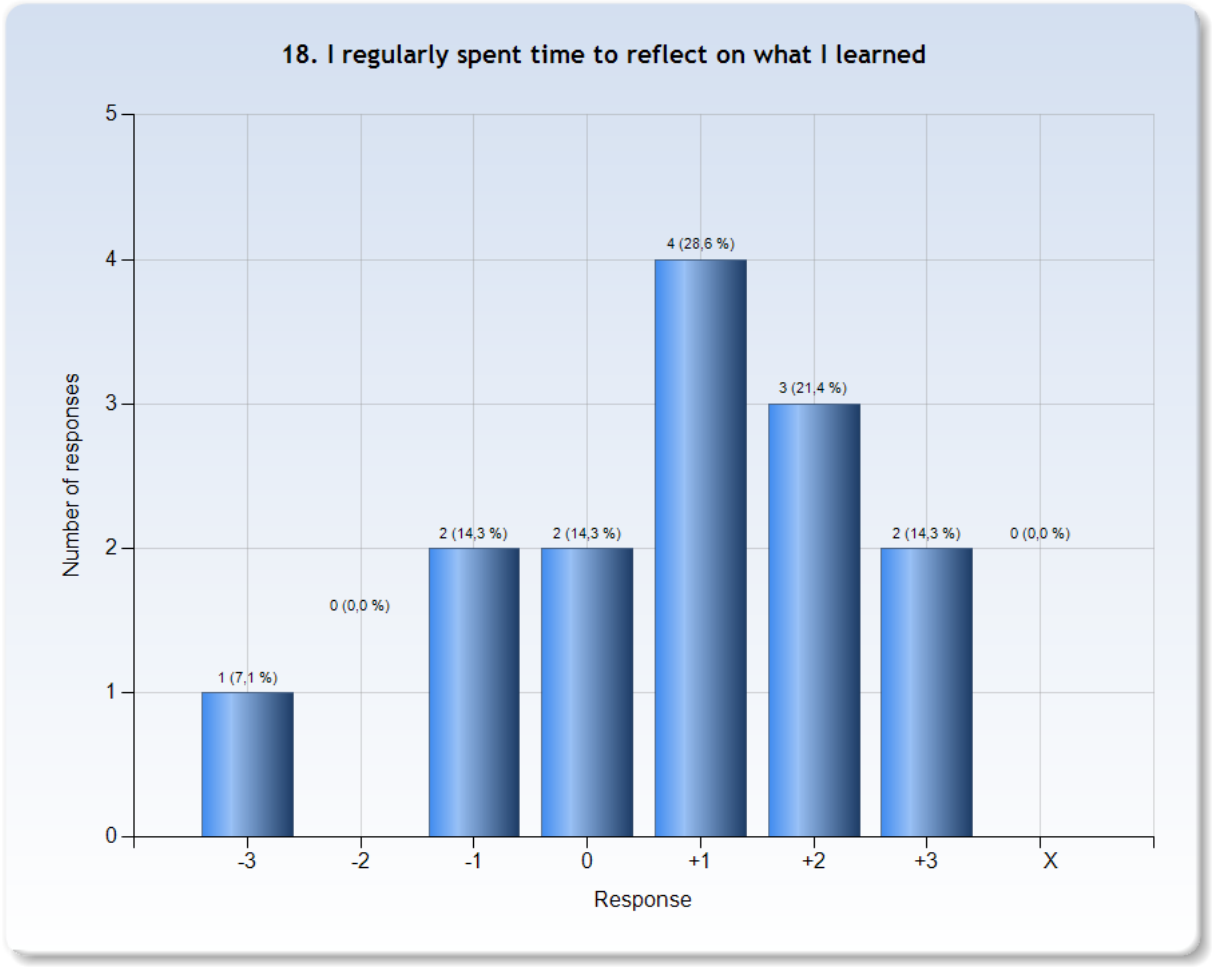
| Comments (My response was: -1) |
| --- |
| I think that the projects were graded too nicely. Not to complain, but a larger effort should be needed for higher grades I believe. |

| Comments (My response was: X ) |
| --- |
| We haven't got back the exam |

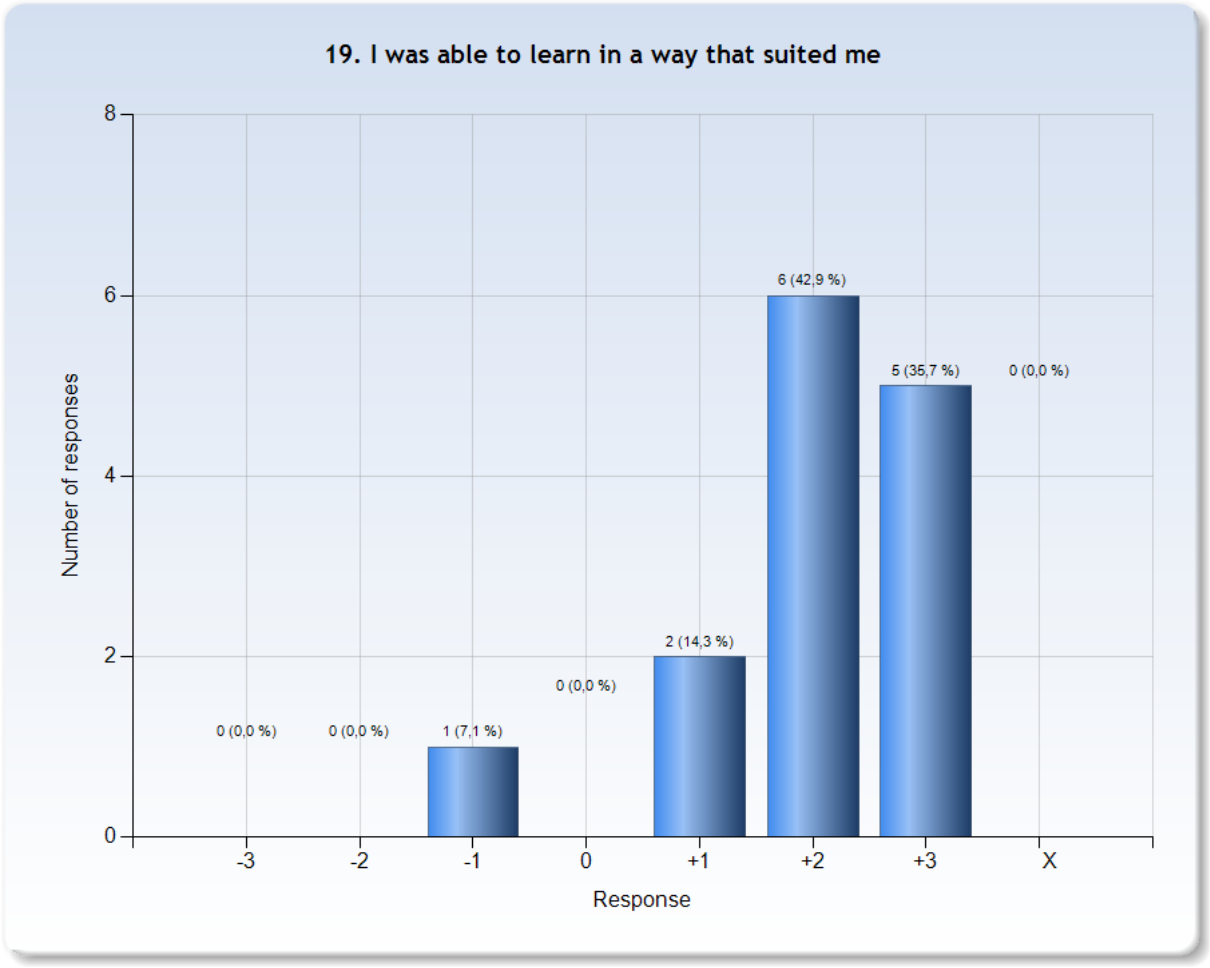



**Comments**

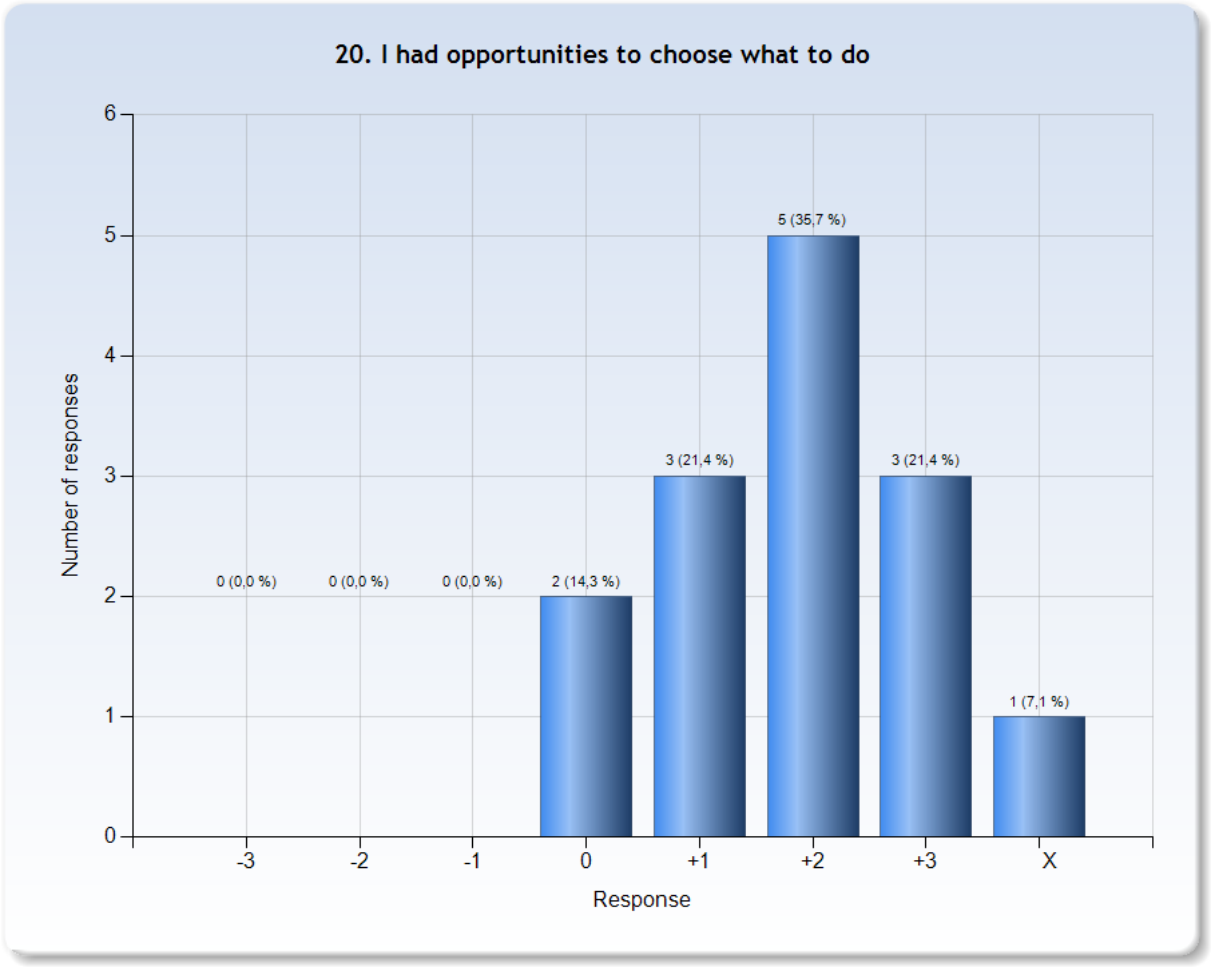
| Comments (My response was: +3) |
| --- |
| You don’t need to take the bachelor course |


18. I regularly spent time to reflect on what I learned
Number of responses
Response
0
1
2
3
4
5
-3
-2
-1
0
+1
+2
+3
X
1 (7,1 %)
0 (0,0 %)
2 (14,3 %)
2 (14,3 %)
4 (28,6 %)
3 (21,4 %)
2 (14,3 %)
0 (0,0 %)

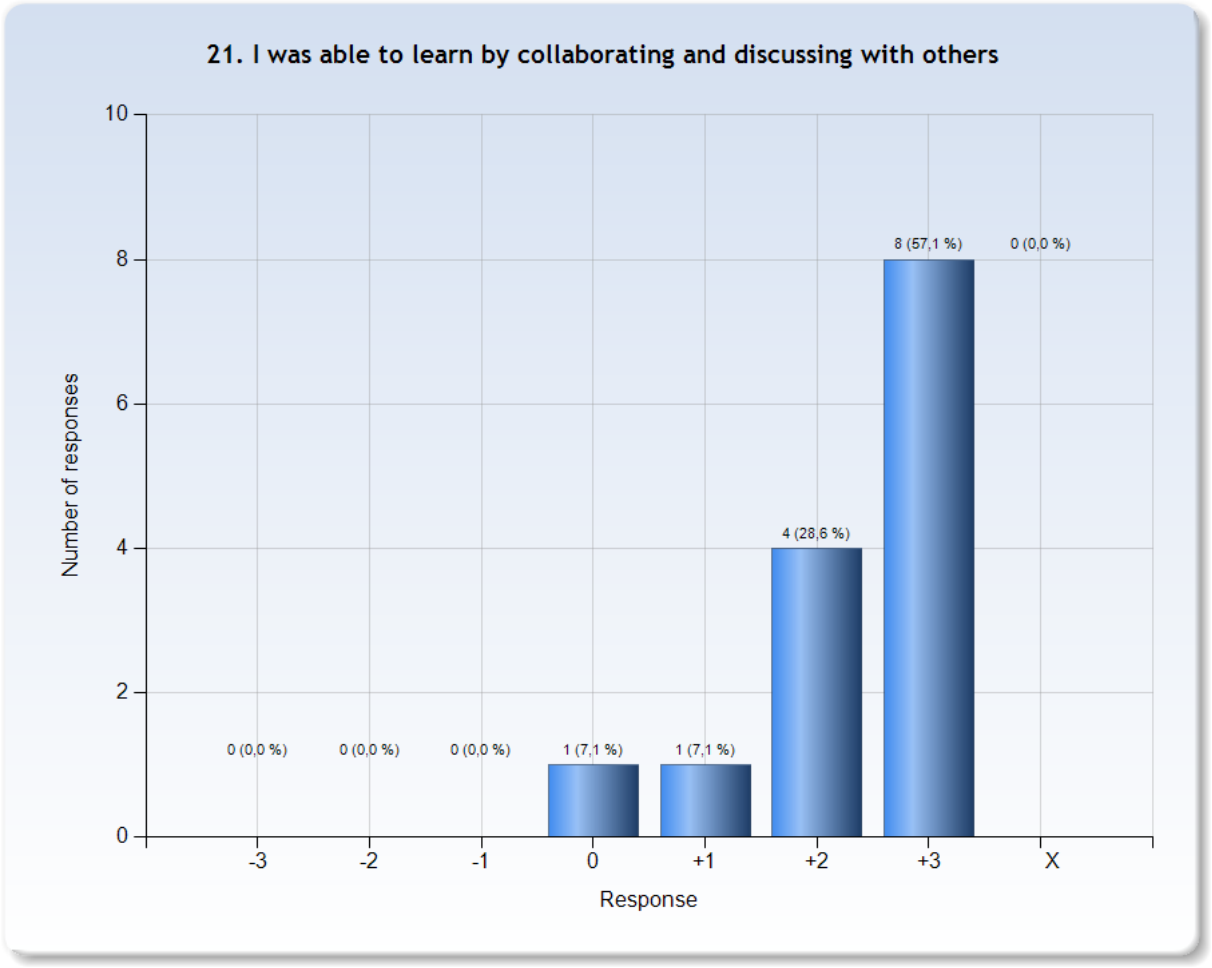
**Comments**


19. I was able to learn in a way that suited me
Number of responses
Response
0
2
4
6
8
-3
-2
-1
0
+1
+2
+3
X
0 (0,0 %)
0 (0,0 %)
1 (7,1 %)
0 (0,0 %)
2 (14,3 %)
6 (42,9 %)
5 (35,7 %)
0 (0,0 %)

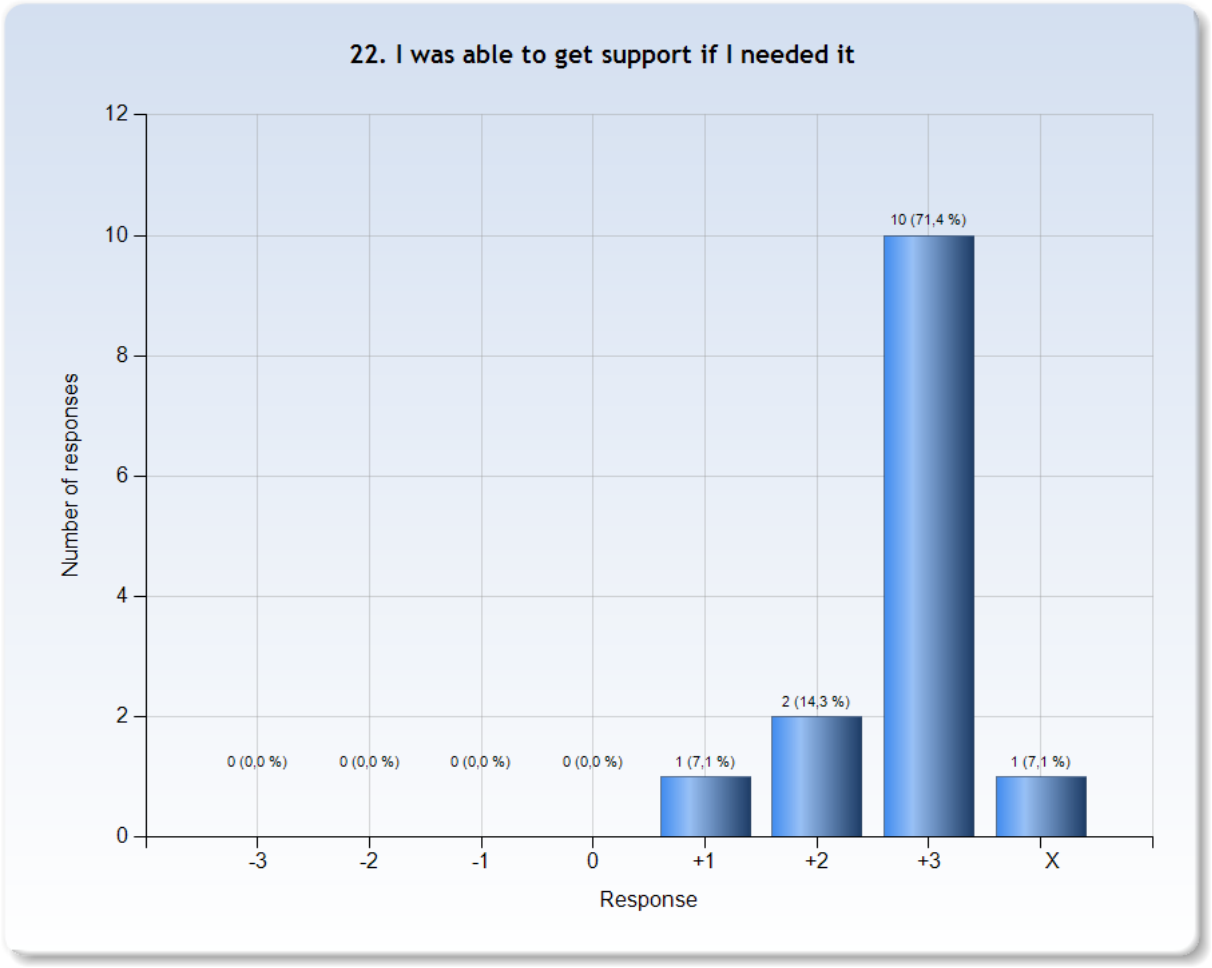
**Comments**


20. I had opportunities to choose what to do
Number of responses
Response
0
1
2
3
4
5
6
-3
-2
-1
0
+1
+2
+3
X
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
2 (14,3 %)
3 (21,4 %)
5 (35,7 %)
3 (21,4 %)
1 (7,1 %)

**Comments**


21. I was able to learn by collaborating and discussing with others
Number of responses
10
8
6
4
2
0
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
1 (7,1 %)
1 (7,1 %)
4 (28,6 %)
8 (57,1 %)
0 (0,0 %)
-3
-2
-1
0
+1
+2
+3
X
Response

**Comments**


22. I was able to get support if I needed it
Number of responses
Response
12
10
8
6
4
2
0
-3
-2
-1
0
+1
+2
+3
X
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
1 (7,1 %)
2 (14,3 %)
10 (71,4 %)
1 (7,1 %)

**Comments**



# SF2812 Applied Linear Optimization, 7.5hp, 2017/2018

## Instructor and examiner

Anders Forsgren (andersf@kth.se), room 3533, Lindstedtsv. 25, tel 790 71 27.
Office hours: Monday 11-12. (Or by agreement.)

## Exercise leader and project leader

David Ek (daviek@kth.se), room 3736, Lindstedtsv. 25, tel. 790 62 94.
Office hours: By agreement.

## Course material

- *Linear and Nonlinear Optimization*, second edition, by I. Griva, S. G. Nash och A. Sofer, SIAM, 2009.
  (The book can be ordered from several places. Please note that you can become a SIAM member for free and obtain a discount at the SIAM bookstore.)
- *Exercises in applied linear optimization, 2017/2018*. Available via Canvas.
- *Lecture notes in applied linear optimization, 2017/2018*. May be downloaded from this web page, see the schedule below. Also available via Canvas.
- *Supplementary course material in applied linear optimization, 2017/2018*. Available via Canvas.
- *Theory questions in applied linear optimization, 2017/2018*. Available via Canvas.
- *GAMS, A user's guide*. Available at the GAMS web site.
- *GAMS*. GAMS is installed in the KTH linux computer rooms. It may also be downloaded from the GAMS web site for use on a personal computer.
- Two project assignments that are handed out during the course, February 1 and February 15 respectively.

Additional notes that may be handed out during the course are also included.

## Course goals

After completed course, the student should be able to:

- explain fundamental concepts of linear programming and integer linear programming;
- explain how fundamental methods for linear programming and integer linear programming work;
- illustrate how these methods work by solving small problems by hand calculations;
- starting from a suitably modified real problem, formulate a linear program or an integer linear program; make a model in a modeling language and solve the problem;
- analyze the solutions of the optimization problem solved, and present the analysis in writing as well as orally;
- interact with other students when modeling and analyzing the optimization problems.

# Examination

The examination is in two parts, projects and final exam. To pass the course, the following requirements must be fulfilled:

- Pass project assignment 1, with presence at the compulsory presentation lecture on Thursday February 15 and presence at the following dicussion session.
- Pass project assignment 2, with presence at the compulsory presentation lecture on Wednesday February 28 and presence at the following dicussion session.
- Pass final exam.

# Course registration

Due to the project based nature of this course, students must register no later than January 31. Registration is made by the students online following KTH standard procedures. PhD students register via e-mail to the instructor.

# Project assignments

The project assignments are performed in groups, where the instructor determines the division of groups. This division is changed between the two assignments. The assignments are carried out by the modeling language GAMS. The project assignments *must* be carried out during the duration of the course and completed by the above mentioned presentation lectures. It is the responsibility of each student to allocate time so that the project group can meet and function. Presence at the presentation lectures is compulsory. For passing the projects, the following requirements must be fulfilled:

- No later than the night before the presentation lecture, each group must hand in a well-written report which describes the exercise and the group's suggestion for solving the exercise through Canvas as a pdf file. Suitable word processor should be used. The report should be on a level suitable for another participant in the course who is not familiar with the group's specific problem.
- When handing in the report, each student should append an individual sheet with a brief self-assessment of his/her contribution to the project work, quantitatively as well as qualitatively.
- At the presentation lecture, all assignments will be presented and discussed. Each student is expected to be able to present the assignment of his/her group, the modeling and the solution. In particular, each student is expected to take part in the discussion. The presentation and discussion should be on a level such that students having had the

same assignment can discuss, and students not having had the same assignment can understand the issues that have arisen and how they have been solved.
- Each group should make an appointment for a discussion session with the course leaders. There is no presentation at this session, but the course leaders will ask questions and give feedback. There will be time slots available the days after the presentation session. One week prior to the presentation lecture, a list of available times for discussion sessions will be made available at Doodle, reachable from the course home page. Each group should sign up for a discussion session prior to the presentation lecture.

Each project assignment is awarded a grade which is either fail or pass with grading E, D, C, B and A. Here, the mathematical treatment of the problem as well as the report and the oral presentation or discussion is taken into account. The exercises are divided into basic exercises and advanced exercises. Sufficient treatment of the basic exercises gives a passing grade. Inclusion of the advanced exercises is necessary for the higher grades (typically A-C). Normally, the same grade is given to all members of a group.

Each group must solve their task independently. Discussion between the groups concerrning interpretation of statements etc. are encouraged, but each group must work independently without making use of solutions provided by others. All groups will not be assigned the same exercises.

# Final exam

The final exam consists of five exercises and gives a maximum of 50 points. At the exam, the grades F, Fx, E, D, C, B and A are awarded. For a passing grade, normally at least 22 points are required. In addition to writing material, no other material is allowed at the exam. Normally, the grade limits are given by E (22-24), D (25-30), C (31-36), B (37-42) and A (43-50).

The grade Fx is normally given for 20 or 21 points on the final exam. An Fx grade may be converted to an E grade by a successful completion of two supplementary exercises, that the student must complete independently. One exercise among the theory exercises handed out during the course, and one exercise which is similar to one exercise of the exam. These exercises are selected by the instructor, individually for each student. Solutions have to be handed in to the instructor and also explained orally within three weeks of the date of notification of grades.

The final exam is given Monday March 12 2018, 8.00-13.00.

# Final grade

By identitying A=7, B=6, C=5, D=4, E=3, the final grade is given as

round( (grade on proj 1) + (grade on proj 2) + 2 * (grade on final exam) ) / 4),

where the rounding is made to nearest larger integer in case of a tie.

# Preliminary schedule

"L" means lecture, "E" means exercise session, "P" means project session.

| Type | Day | Date | Time | Room | Subject |
|---|---|---|---|---|---|
| L1. | Tue | Jan 16 | 15-17 | U21 | Introduction. Linear programming models. (pdf) |
| L2. | Thu | Jan 18 | 8-10 | U21 | Linear programming. Geometry. (pdf) |
| L3. | Fri | Jan 19 | 15-17 | U21 | Lagrangian relaxation. Duality. LP optimality. (pdf) |
| L4. | Tue | Jan 23 | 15-17 | U21 | Linear programming. The simplex method. (pdf) |
| E1. | Thu | Jan 25 | 8-10 | U21 | Linear programming. The simplex method. |
| L5. | Fri | Jan 26 | 15-17 | U21 | More on the simplex method. (pdf) |
| E2. | Tue | Jan 30 | 15-17 | U21 | Linear programming. The simplex method. |
| P1. | Wed | Jan 31 | 10-12 | U21 | Introduction to GAMS. (pdf) |
| P2. | Thu | Feb 1 | 8-10 | Gul | GAMS excercise session. |
| L6. | Fri | Feb 2 | 15-17 | U21 | Stochastic programming. (pdf) |
| E3. | Tue | Feb 6 | 15-17 | U21 | Stochastic programming. |
| L7. | Thu | Feb 8 | 8-10 | U21 | Interior methods for linear programming. (pdf) |
| E4. | Fre | Feb 9 | 15-17 | U21 | Interior methods for linear programming. |
| L8. | Tue | Feb 13 | 15-17 | U21 | Integer programming models. (pdf) |
| L9. | Wed | Feb 14 | 10-12 | U21 | Branch-and-bound. (pdf) |
| P3. | Thu | Feb 15 | 8-10 | U21 | Presentation of project assignment 1. |
| E5. | Fri | Feb 16 | 15-17 | U21 | Integer programming. |
| L10. | Tue | Feb 20 | 15-17 | U21 | Decomposition and column generation. (pdf) |
| E6. | Thu | Feb 22 | 8-10 | U31 | Decomposition and column generation. |
| L11. | Fri | Feb 23 | 15-17 | U21 | Lagrangian relaxation. Duality. (pdf) |
| E7. | Tue | Feb 27 | 15-17 | U31 | Lagrangian relaxation. Duality. |
| P4. | Wed | Feb 28 | 10-12 | U21 | Presentation of project assignment 2. |
| L12. | Thu | Mar 1 | 8-10 | U31 | Subgradient methods. (pdf) |
| E8. | Fri | Mar 2 | 15-17 | L52 | Subgradient methods. |

# Mapping of exercises to lectures

The sections in the exercise booklet may roughly be mapped to the lectures as follows:

- 1. The simplex method. After L4.
- 2. Sensitivity analysis. After L4.
- 3. Interior point methods. After L7.
- 4. Decomposition and column generation. After L10.
- 5. Linear programming - remaining. After L7.
- 6. Stochastic programming. After L6.
- 7. Formulation - integer programming. After L8.
- 8. Lagrangian relaxation and duality. After L11.
- 9. Subgradient methods. After L12.

# Overview of course contents

- **Linear programming**
  Fundamental LP theory with corresponding geometric interpretations. The simplex method. Column generation. Decomposition. Duality. Complementarity. Sensitivity. Formulations of LPs. Interior methods for linear programming, primal-dual interior methods in particular.
  (Chapters 4-7 in Griva, Nash and Sofer, except 5.2.3, 5.2.4, 5.5.1, 6.5, 7.5, 7.6. Chapter 9.3 in Griva, Nash and Sofer. Chapter 10 in Griva, Nash and Sofer, except 10.3, 10.5.)
- **Stochastic programming**
  Fundamental theory. (Supplementary course material.)
- **Integer programming**
  Formulations of integer programs. Branch-and-bound. Lagrangian relaxation and subgradient methods applied on integer programs with special structure.
  (Supplementary course material.)

# Welcome to the course!

Course home page: http://www.math.kth.se/optsyst/grundutbildning/kurser/SF2812/.

**Published by: Optimization and Systems Theory, KTH**
**Anders Forsgren, andersf@kth.se**
Last updated: 2018-01-23