Report - SF2812 - 2017-06-26

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 exercises 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 presentation 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 had the “follow-up” discussions with the groups after the presentation lectures.
As earlier years I used laptop and projector 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 problem by using GAMS and Matlab.
David Ek was teaching assistant in the course, replacing Axel Ringh. This was his first time with this course.

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 or slightly above 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 is slightly higher.

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 result in this course have overall been very good, I would say. The course has grown over the years, I think mostly with an increase of students from industrial engineering. In addition, there are many exchange students. We had 64 master students and two PhD students completing the projects this year. Last year was similar.
The result on the final exam, however, was significantly different from previous years. On the initial final exam, 26% of the master students failed. The grade distribution A-E was not unusual if excluding the F's.
I also noted that some more students than I remember from earlier years did not do the advanced exercises in the projects, only the basis ones.
The growth of the course has created some difficulties. There are students that have not taken a basic optimization course for which this one is compulsory. We have arranged to give a basic optimization course in period 2, which is suitable for them. This requires, however, that there is room for them to take the course in their program. This is a difficulty which I will have to discuss with the program directors.
Also, the course being compulsory for some programs is not something I prefer. The setup of the course is intended for students who want to take the course, not students who must take it even if they do not want to.

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?

I think the overall impression of the learning environment is good. This is what I would expect, based on 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 very high marks. I think this is due to the setup of the projects and the way we give feedback. This is in my opinion a strength of the course. A weakness is that the students do not get to choose groups and choose projects. This is a consequence of us making the division of groups, and I think there is an overall benefit of doing it this way.

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 is clear that the students understand the setup of the course and most of them also appreciate it. I think it would be very good for future students to read the advice given. As previous years, I browsed them at the first lecture.

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. The self-assessment form might be improved. This is the form where the student says what he/she did in the project. In the long run it would also be interesting to try different forms of teaching, for example to put the lectures on video, or make shorter introductory videos.

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 was a good teaching assistant, this was his first time.

Course data 2017-06-26

SF2812 - Applied Linear Optimization, VT 2017

Course facts

Course start:	2017 w.3
Course end:	2017 w.11
Credits:	7,5
Examination:	PRO1 - Project, 1.5, Grading scale: A, B, C, D, E, FX, F PRO2 - Project, 1.5, Grading scale: A, B, C, D, E, FX, F 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> Axel Ringh <aringh@kth.se>
Assistants:	David Ek <daviek@kth.se>

Number of students on the course offering

First-time registered:	77
Total number of registered:	86

Achievements (only first-time registered students)

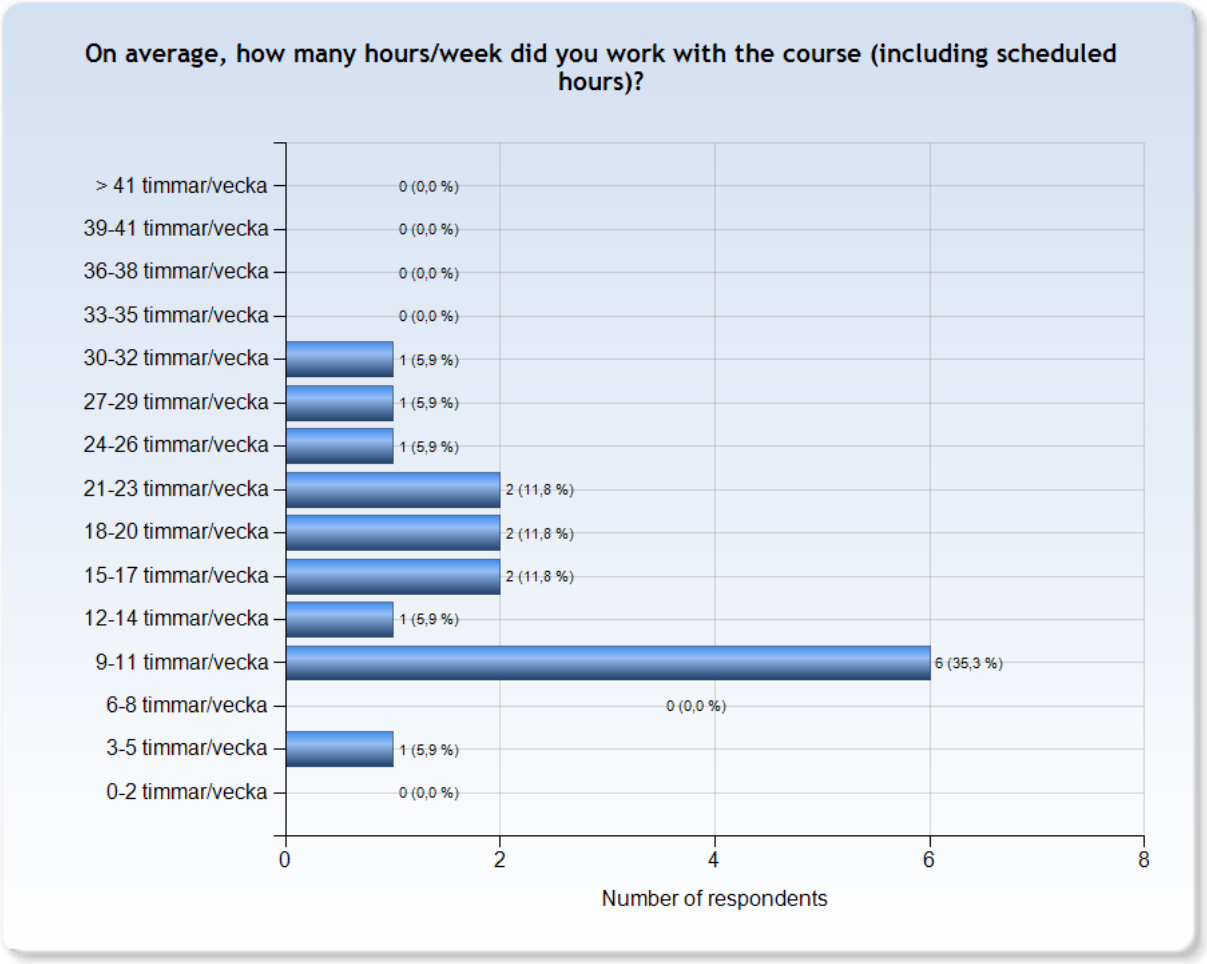
Pass rate[1] [%]	68.80%
Performance rate[2] [%]	79.70%
Grade distribution[3] [%, number]	A 21% (11) B 32% (17) C 42% (22) D 6% (3)

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

SF2812 - 2017-03-16

Antal respondenter: 77
Antal svar: 17
Svarsfrekvens: 22,08 %

ESTIMATED WORKLOAD



Comments

Comments (I worked: 9-11 timmar/vecka)
Theory questions to prepare + projects

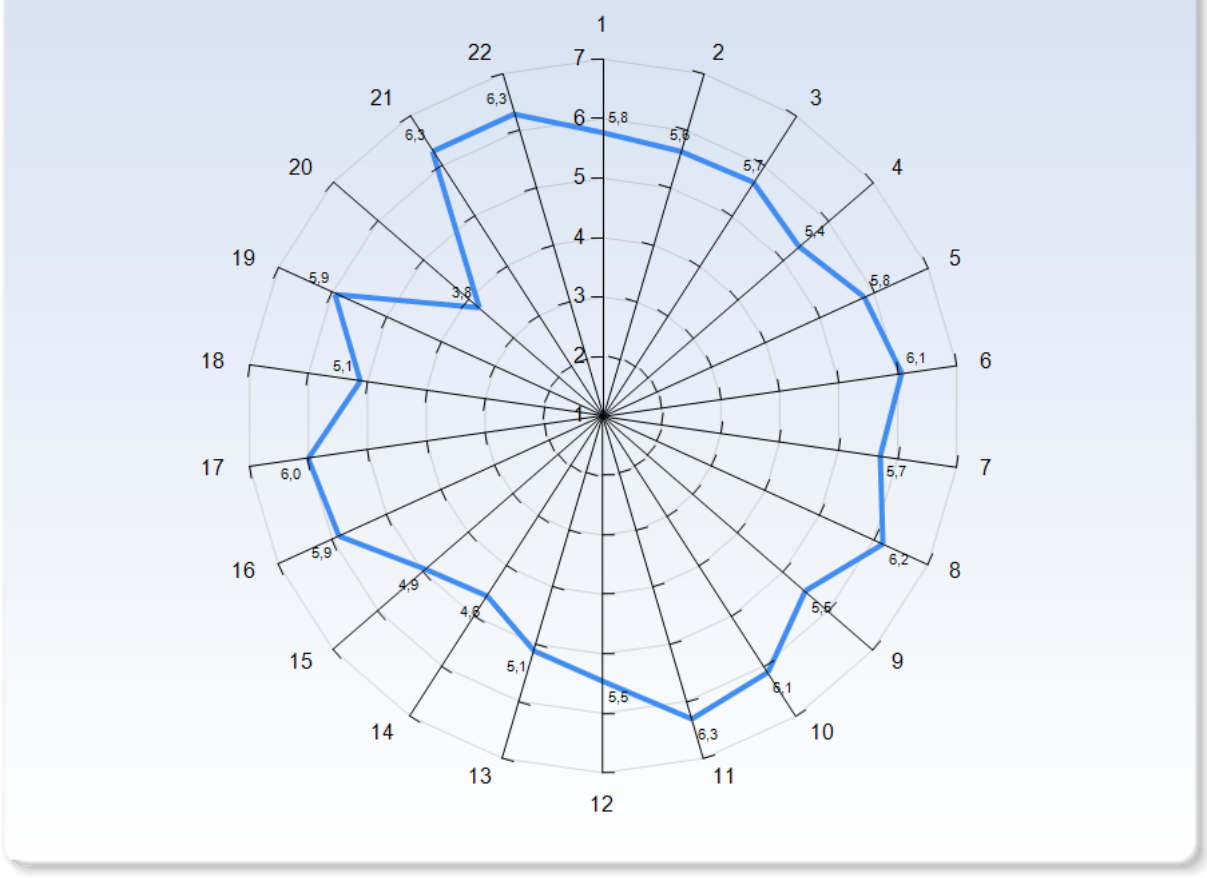
Comments (I worked: 18-20 timmar/vecka)
The course has a workload at the limit of what you can expect for a 7.5 credit course. But it is hard to squeeze this by working effieciently as I was used to before. So this course's workload is fine if you have 15 credits per period.

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
5,8
5,6
5,7
5,4
5,8
6,1
5,7
6,2
5,6
6,1
6,3
5,5
5,1
4,6
4,9
5,9
6,0
5,1
5,9
3,8
6,3
6,3

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.

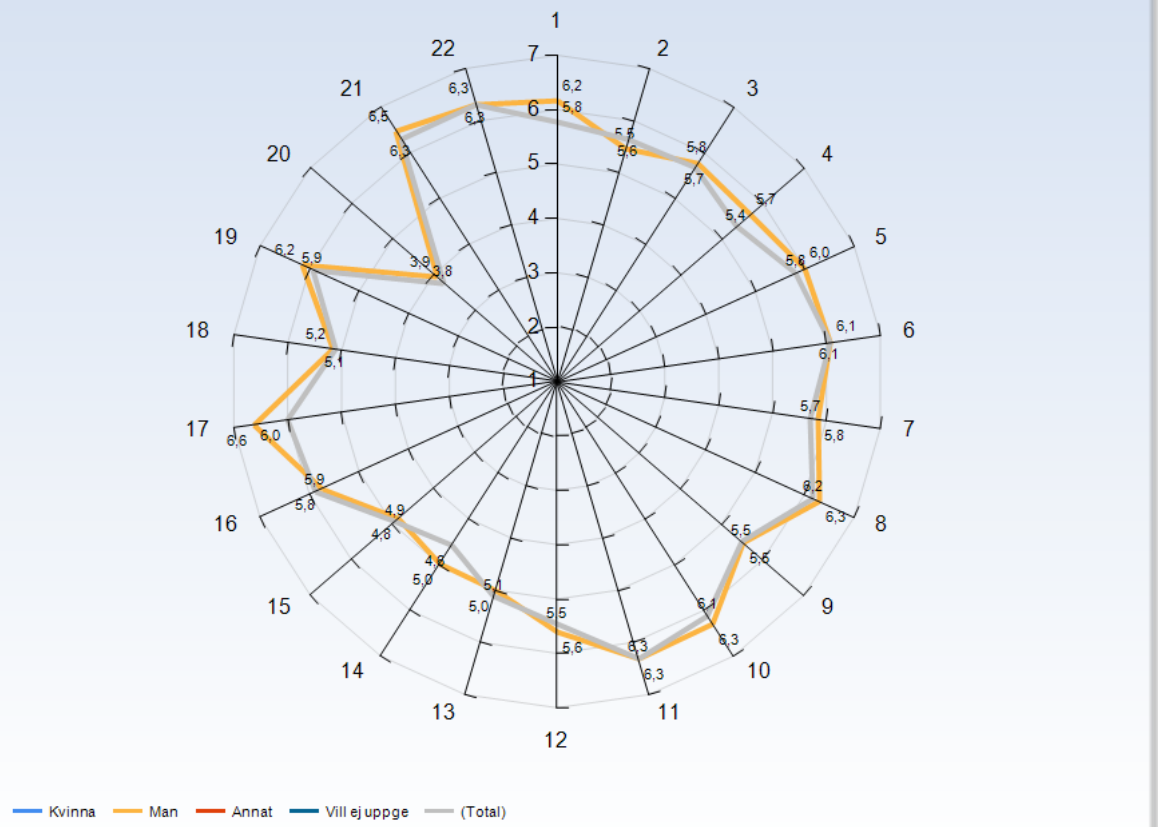
Biggs J. & Tang, C. (2011). *Teaching for Quality Learning at University*, Chapter 6, pp. 95-110. Maidenhead: McGraw Hill.

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

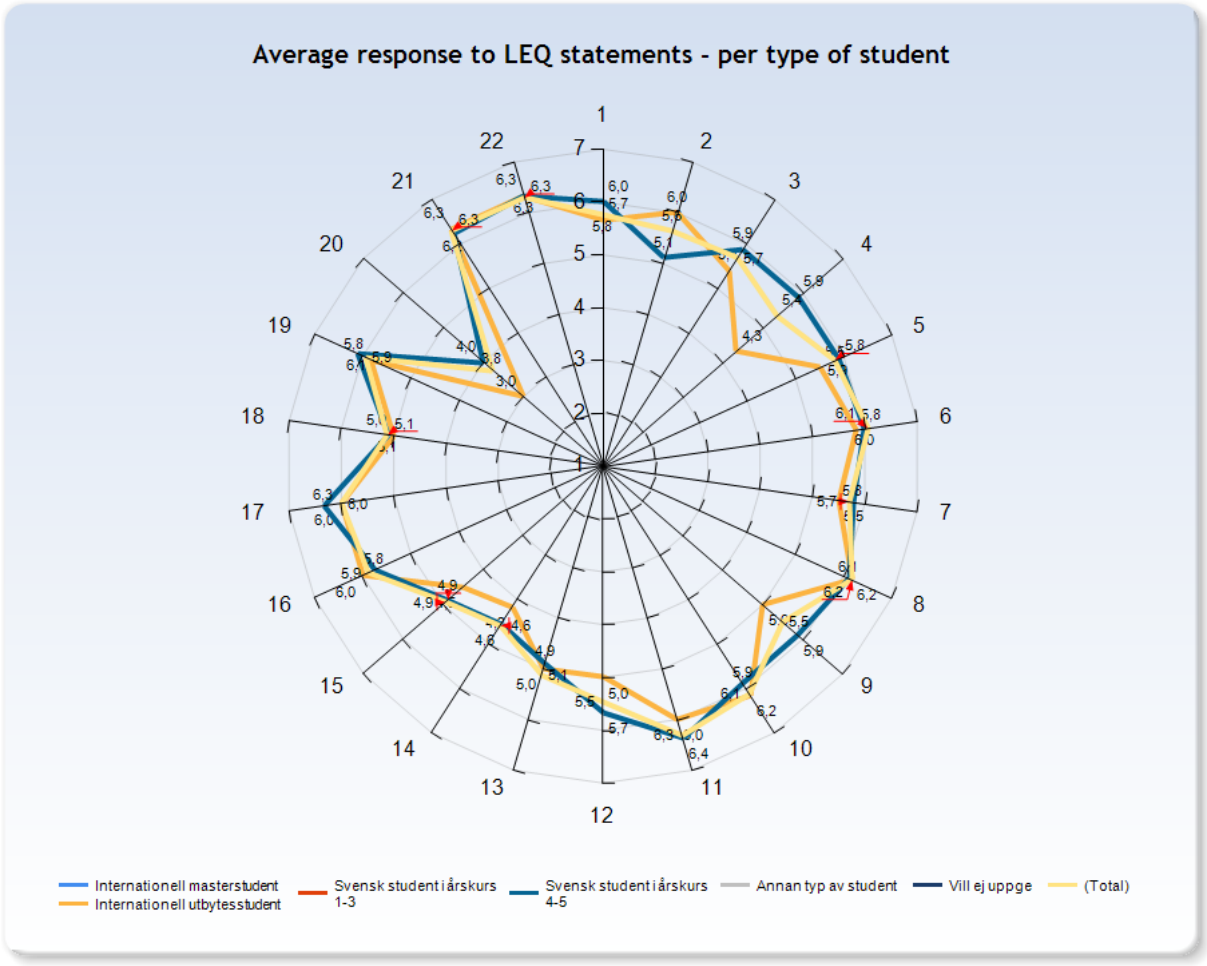
Kember, K. & McNaught, C. (2007). *Enhancing University Teaching: Lessons from Research into Award-Winning Teachers*, Chapter 5, pp. 31-40. Abingdon: Routledge.

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

Average response to LEQ statements - per gender



Comments



Comments

Comments (I am: Internationell utbytesstudent)
TIME double degree student

GENERAL QUESTIONS

What was the best aspect of the course?

What was the best aspect of the course? (I worked: 3-5 timmar/vecka)
Using the knowledge by solving problems in GAMS.

What was the best aspect of the course? (I worked: 9-11 timmar/vecka)
There was a good amount of practical work in addition to the theoretical parts, so it was easy to get a grasp on the subject matter.
It's 7.5 credits
The projects were very interesting and the group work related to it too!

What was the best aspect of the course? (I worked: 12-14 timmar/vecka)
Anders föreläsningar håller mycket hög kvalitet. Eftersom kursen har getts så många gånger märker man att Anders vet vad som fungerar bra och vad som fungerar mindre bra. Därmed, fortsätt på den utstakade vägen! Bra slides. Bra att första föreläsningen är endast introduktion och inte behandlar teori. Davids övningar var också mycket bra. Bra att uppgifterna på seminarierna är lika tentauppgifterna. Jag gillade sammanfattningen David gjorde på primal/dual simplex som fanns på canvas. Om det inte är för mycket jobb skulle en liknande sammanfattning till andra övningar också. Projekten var roliga! Jag tyckte framförallt projekt 2 var kul och var lätt att relatera till. Tentan var rättvis och gick igenom de moment som varit centrala i kursen, bra. Jag kan tycka att sista uppgiften på tentan var lite väl svår och lite binär, med tanke på att b-uppgiften var en direkt följdfråga på a-uppgiften. Kanske är jag här lite biased eftersom jag inte fick ut sista uppgiften, men ändå. Också bra att uppgiften om interior methods gjorts om från tidigare år (skriva upp en matrisekvation och sen sätta in numeriska värden är 7 väldigt billiga poäng).

What was the best aspect of the course? (I worked: 15-17 timmar/vecka)
Project part where we are able to apply the knowledge to some real problem.

What was the best aspect of the course? (I worked: 18-20 timmar/vecka)
Projects, both in content (relevant problems related to possible "real" problems) and working in groups
I enjoyed the project work. It was nice to implement what I had just learned.

What was the best aspect of the course? (I worked: 21-23 timmar/vecka)
The group projects

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

What was the best aspect of the course? (I worked: 30-32 timmar/vecka)
Learning about the different linear/integer programming models, e.g. the knapsack problem, the general assignment problem, etc. and their characteristics.

What would you suggest to improve?

What would you suggest to improve? (I worked: 3-5 timmar/vecka)
In the assignments, we only need to make a linear program, and then GAMS will solve it for us. However, I think the main idea of the course is how to solve the linear program.

What would you suggest to improve? (I worked: 9-11 timmar/vecka)
Some exercises were solved too quickly during the exercise sessions

What would you suggest to improve? (I worked: 12-14 timmar/vecka)
Studenterna bör själva få välja grupper till projekten. I de två grupperna jag hamnade i hade vi alla jag och de andra två gruppmedlemmarna helt olika ambitionsnivåer med projekten. Eftersom jag siktade på de höga betygen och de andra två nöjde sig med pass slutade det med att jag själv fick göra advanced exercises. I self-assessments skrev däremot de båda att de varit delaktiga i advanced och vi fick samma betyg. Därför föreslår jag följande förändring: De som vill välja grupper själva får maila Anders om förslag till gruppindelning. Self-assessment bifogas inte längst bak i rapporten för då kommer de andra gruppmedlemmarna se vad andra skrivit vilket ger utrymme för diskussioner om vem som gjort vad. Låt varje gruppmedlem ha med utskriven och ifylld self-assessment till feedbacksmötet istället.

What would you suggest to improve? (I worked: 15-17 timmar/vecka)
Instructions to write a report and present it.

What would you suggest to improve? (I worked: 18-20 timmar/vecka)
GAMS introduction was a bit messy, took a lot of experimenting to learn
If you don't give specific requirements for the project work, please add a prediscussion about the group's line-up or ideas about what to include in the project work. It's unrealistic that there is no feedback from a customer during implementation of a project. If you put general requirements into the project and then base the grade on stuff that is not even closely covered in the projects description I feel treated unjustly.

What would you suggest to improve? (I worked: 30-32 timmar/vecka)
I think the conditions for each grade for the group projects should be made more clear, for example that you're supposed to calculate EVPI and VSS if you want an A. This should be part of the assignment.

What advice would you like to give to future participants?

What advice would you like to give to future participants? (I worked: 9-11 timmar/vecka)
Work continually.
Take this course
Do not forget to prepare the theory questions, it will make you save time when working for the exam Take time to work on the projects

What advice would you like to give to future participants? (I worked: 12-14 timmar/vecka)
Lär er teorifrågorna bra och längs med kursen! Framförallt de första teorifrågorna återkommer senare under kursen. Blir så mycket lättare att hänga med på föreläsningarna om man fattat tidigare föreläsningars teorifrågor.

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

What advice would you like to give to future participants? (I worked: 18-20 timmar/vecka)
Don't be afraid to go off on interesting tangents in the projects. Also, exams are very consistent in content.
This course is exactly like it is described. It is applied. This is the most fun part and probably most helpful for understanding. But don't forget to start early with just the normal learning by heart and performing methods by heart stuff as your grade is halfly based on exactly this.

What advice would you like to give to future participants? (I worked: 30-32 timmar/vecka)
Just study hard, make sure that you know how to use the different models, and learn about the different types of optimization techniques.

Is there anything else you would like to add?

Is there anything else you would like to add? (I worked: 9-11 timmar/vecka)
Nothing

Is there anything else you would like to add? (I worked: 12-14 timmar/vecka)
En av de bästa, om inte den bästa, kursen jag läst på KTH.

Is there anything else you would like to add? (I worked: 15-17 timmar/vecka)
Temporarily no.

Is there anything else you would like to add? (I worked: 18-20 timmar/vecka)
no
Pls choose tutors also based on their ability to teach. The exercise session was not helpful at all. Not because of the chosen content, but because of the teacher. I could see he knows his stuff, but he spoke too low even after suggesting to be louder, he spoke a horrible english swedish mixture (Even though I understand both languages it was terrible) and almost always faced the wall. All in all it was wasted time.

Is there anything else you would like to add? (I worked: 24-26 timmar/vecka)
I liked the course very much!

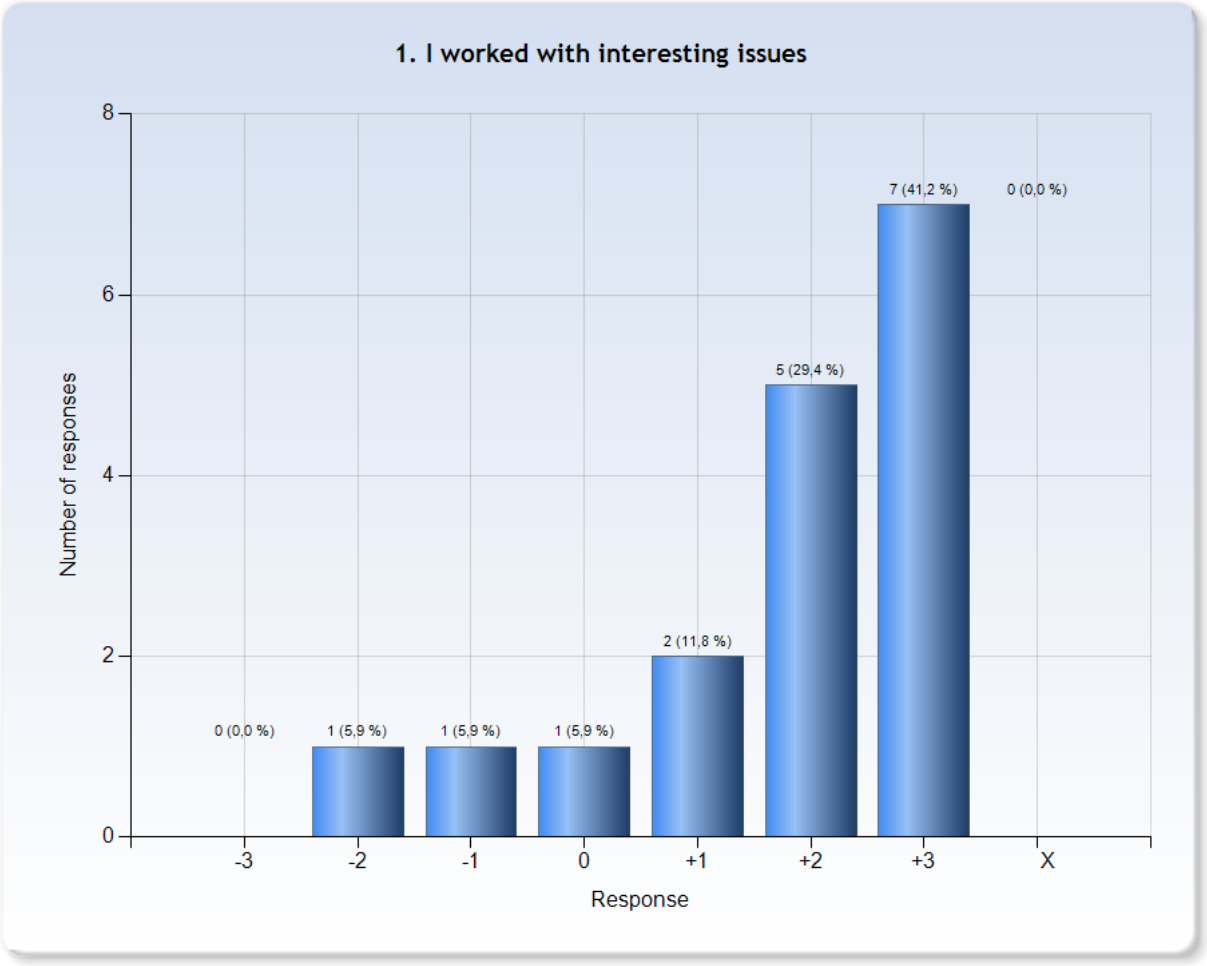
SPECIFIC QUESTIONS

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



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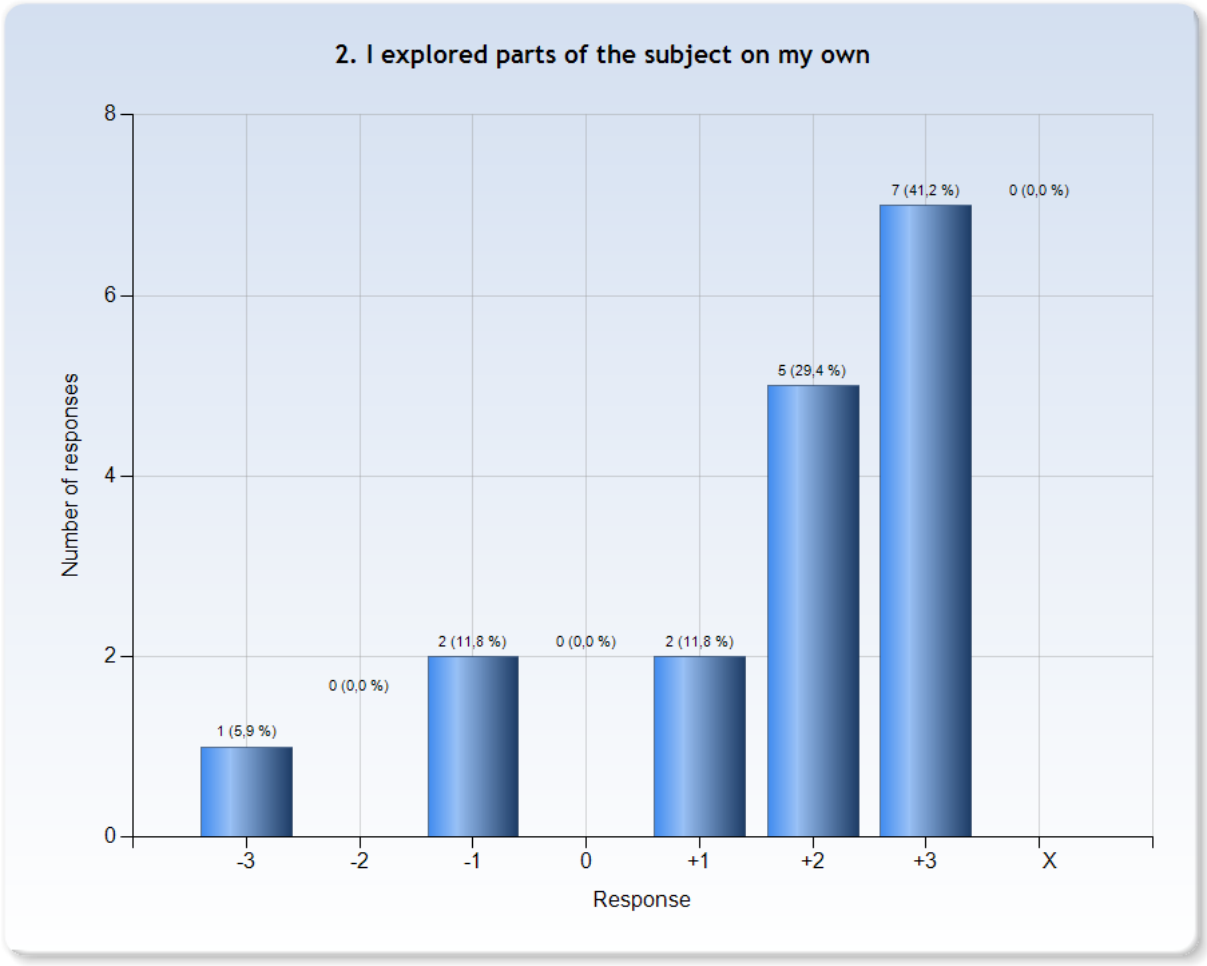
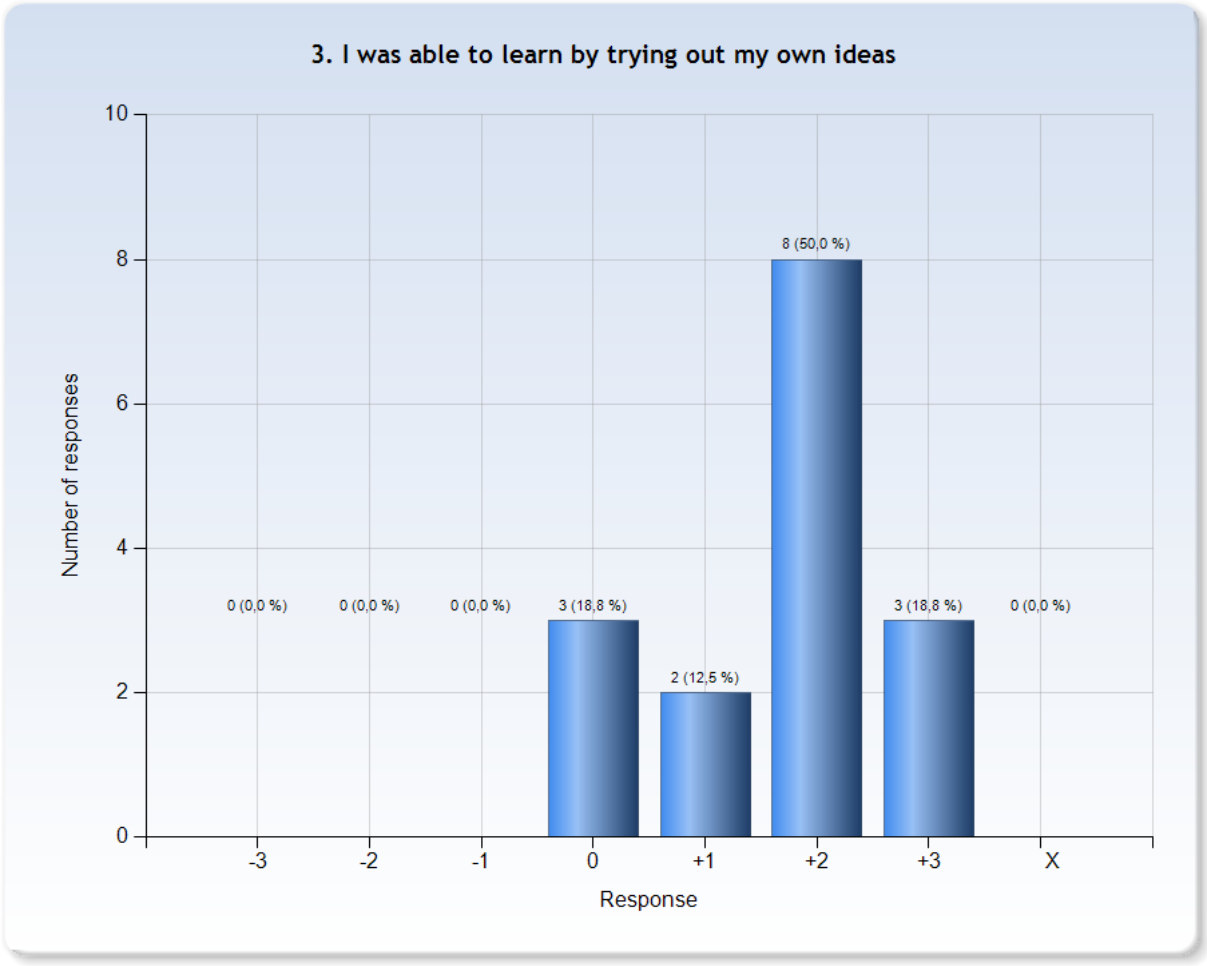
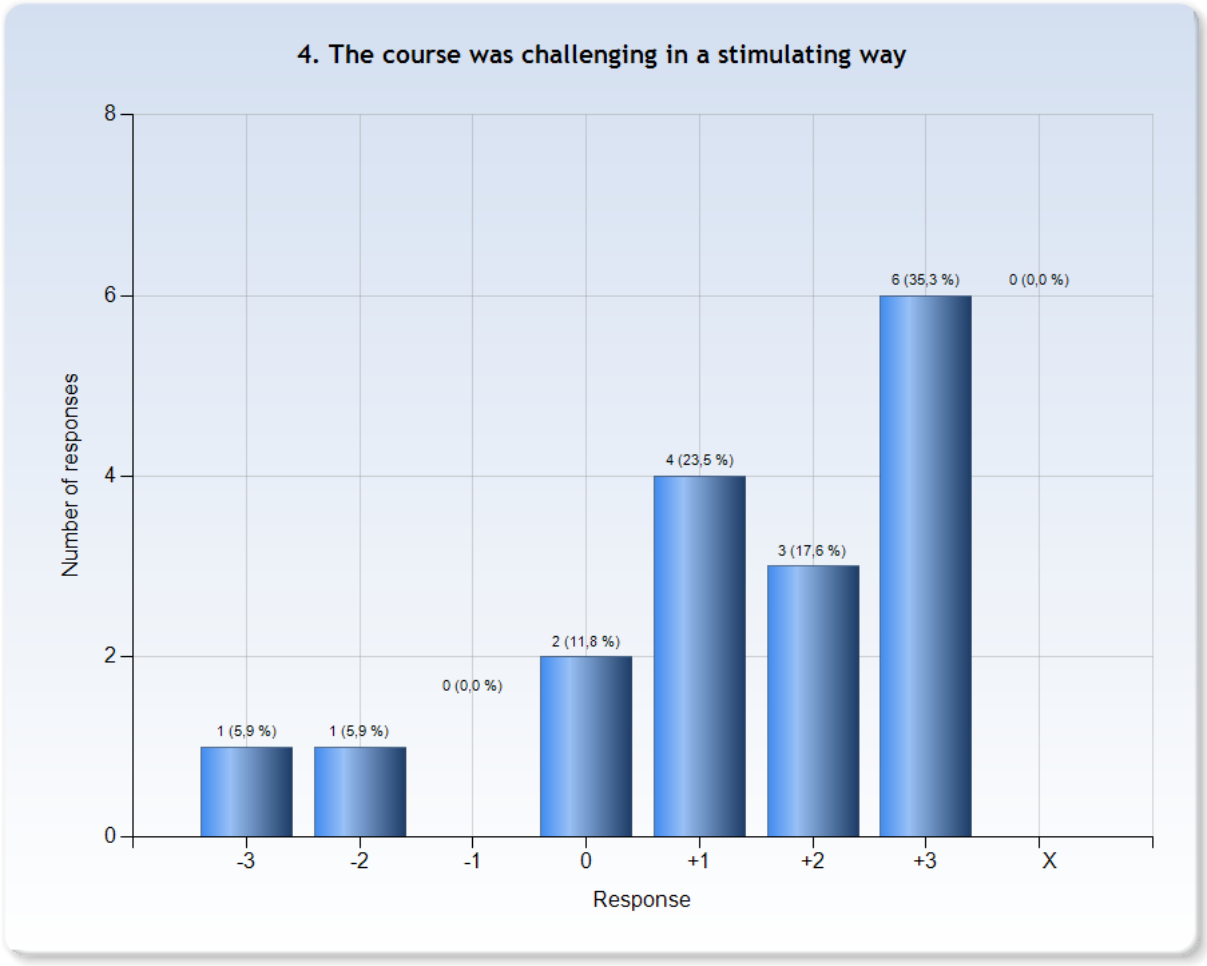

2. I explored parts of the subject on my own
Number of responses
Response
0
2
4
6
8
-3
-2
-1
0
+1
+2
+3
X
1 (5,9 %)
0 (0,0 %)
2 (11,8 %)
0 (0,0 %)
2 (11,8 %)
5 (29,4 %)
7 (41,2 %)
0 (0,0 %)

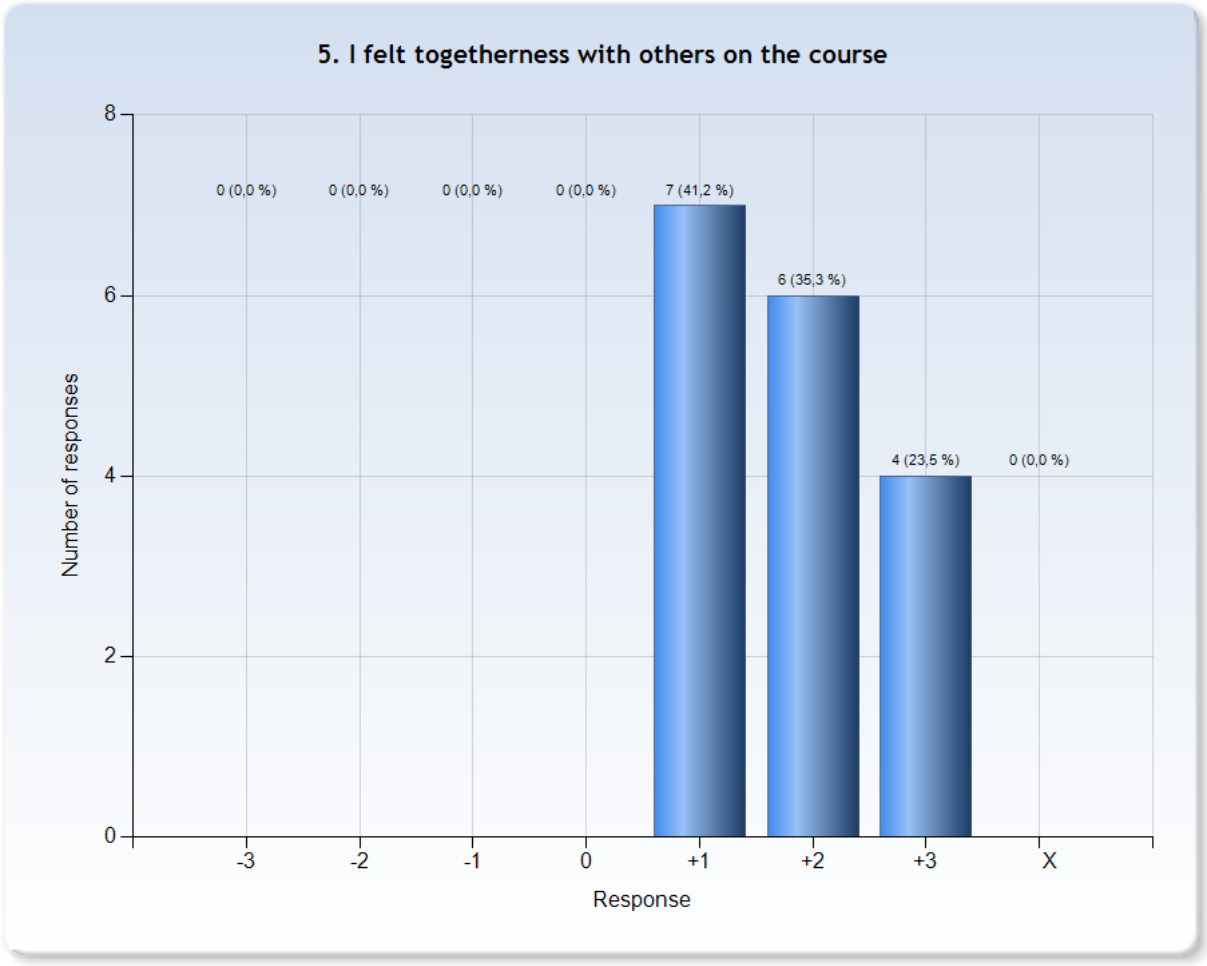
Comments


3. I was able to learn by trying out my own ideas
Number of responses
10
8
6
4
2
0
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
3 (18,8 %)
2 (12,5 %)
8 (50,0 %)
3 (18,8 %)
0 (0,0 %)
-3
-2
-1
0
+1
+2
+3
X
Response

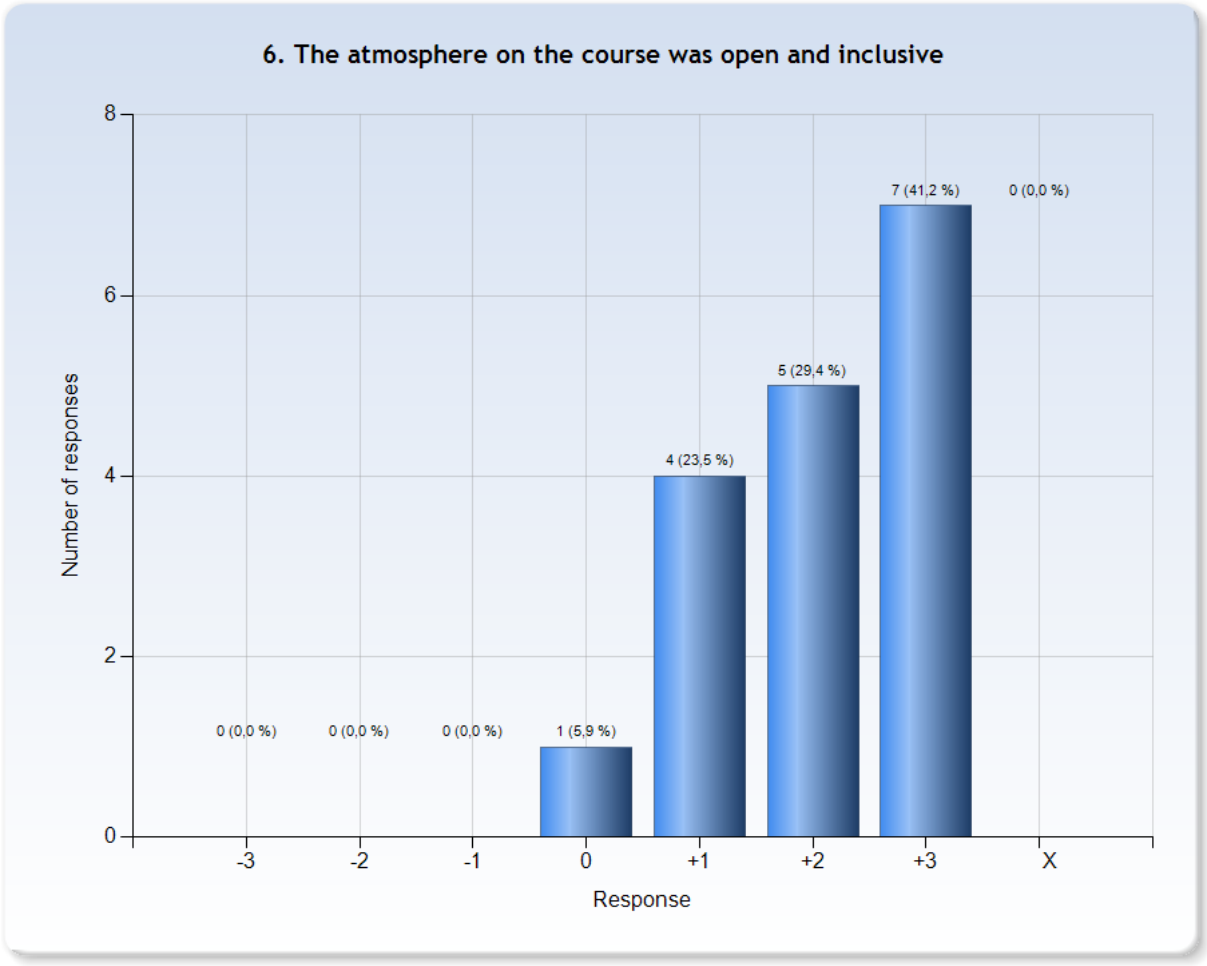
Comments


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
1 (5,9 %)
1 (5,9 %)
0 (0,0 %)
2 (11,8 %)
4 (23,5 %)
3 (17,6 %)
6 (35,3 %)
0 (0,0 %)

Comments

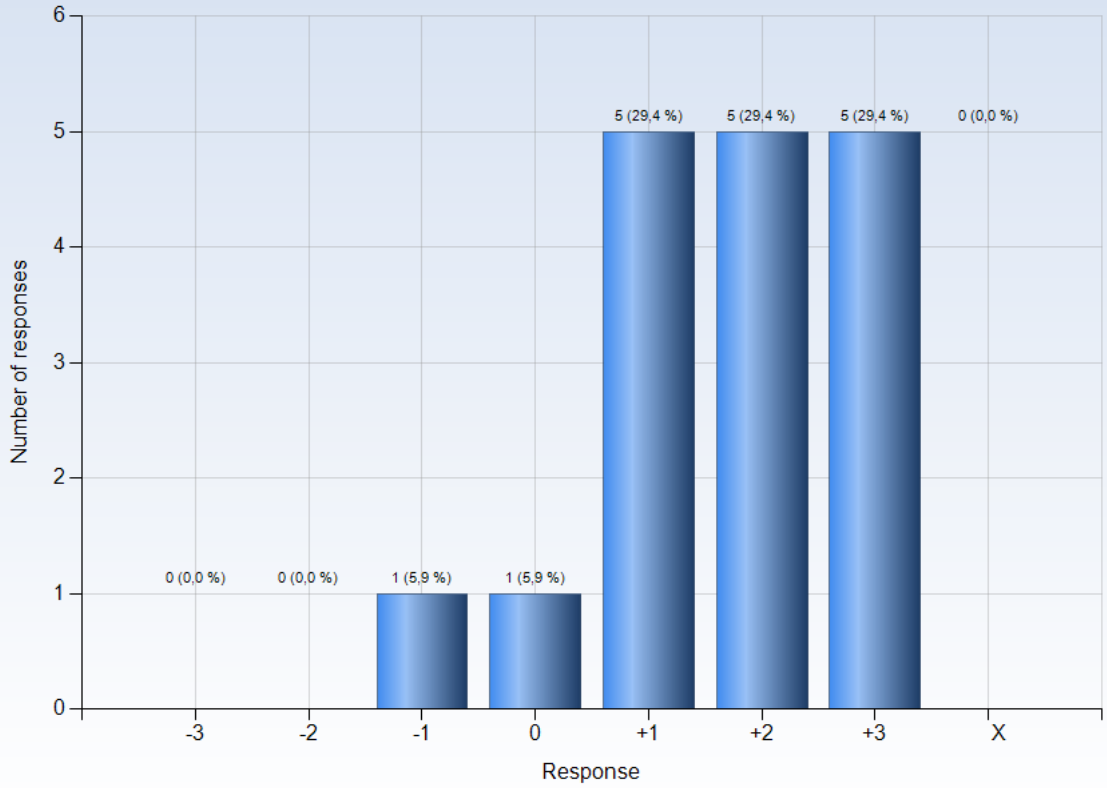

5. I felt togetherness with others on the course
Number of responses
Response
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
7 (41,2 %)
6 (35,3 %)
4 (23,5 %)
0 (0,0 %)
-3
-2
-1
0
+1
+2
+3
X
0
2
4
6
8

Comments

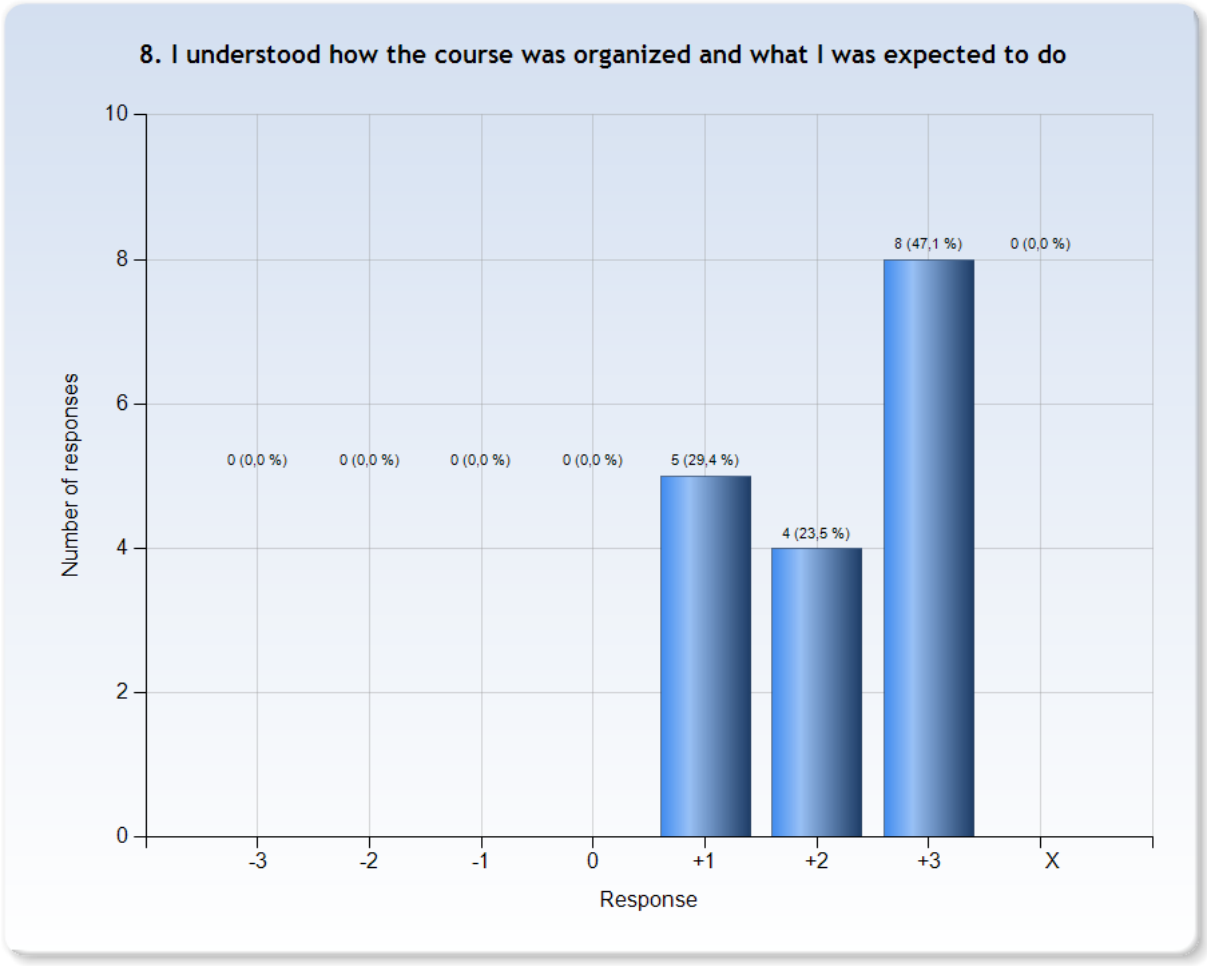

6. The atmosphere on the course was open and inclusive
Number of responses
8
6
4
2
0
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
1 (5,9 %)
4 (23,5 %)
5 (29,4 %)
7 (41,2 %)
0 (0,0 %)
-3
-2
-1
0
+1
+2
+3
X
Response

Comments

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

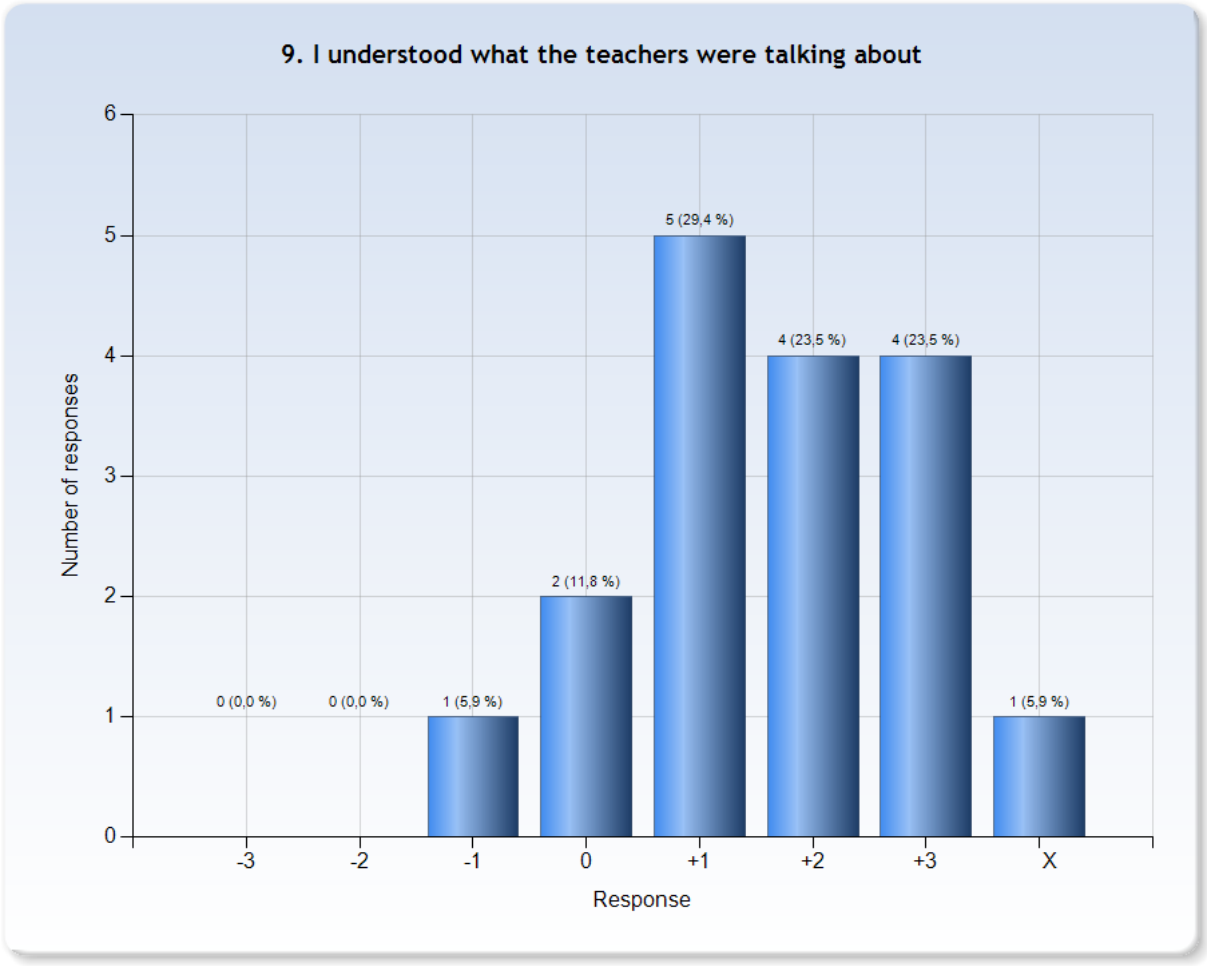


Comments



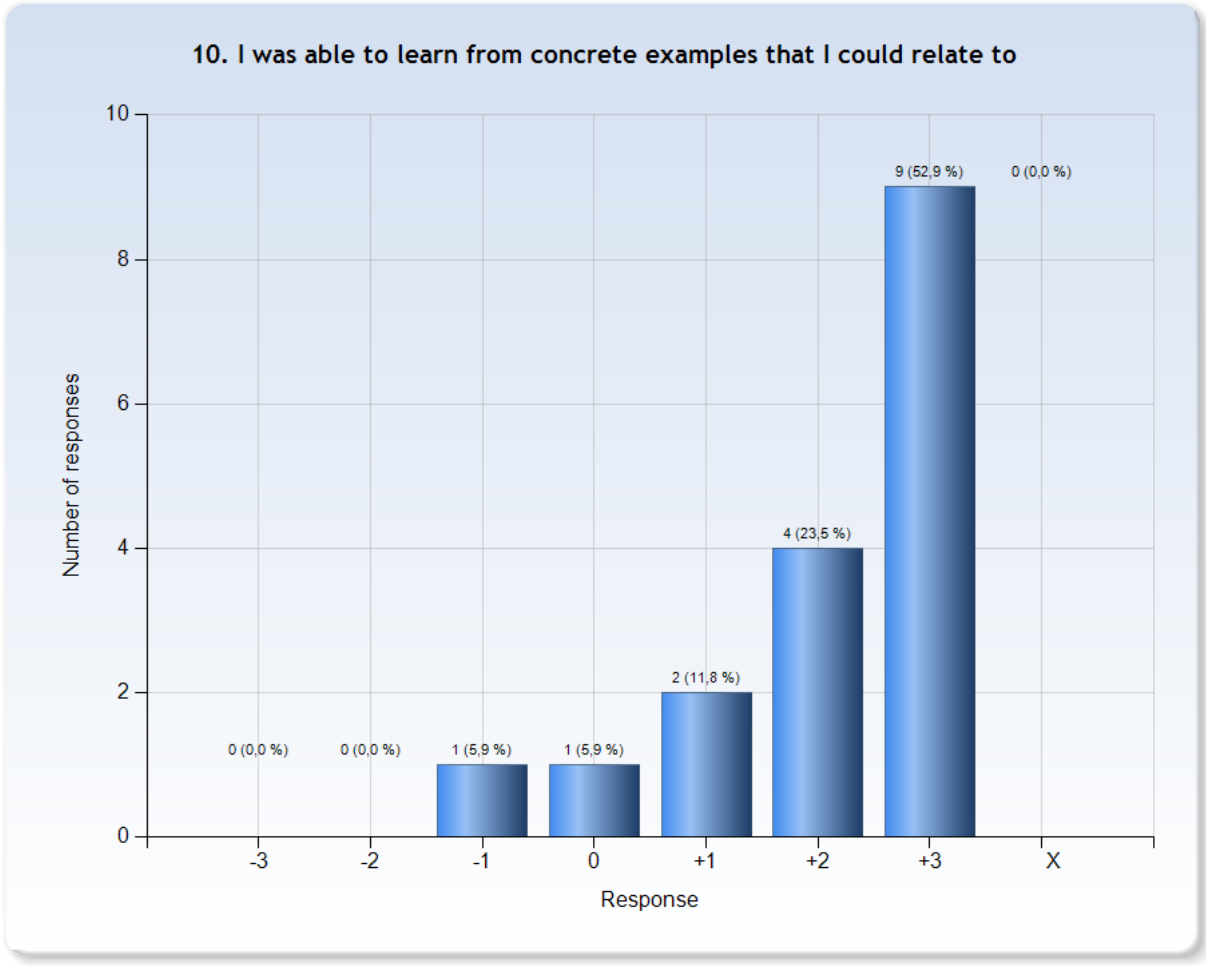
Comments

Comments (My response was: +3)
You summarized well how to study for the course. Thanks!

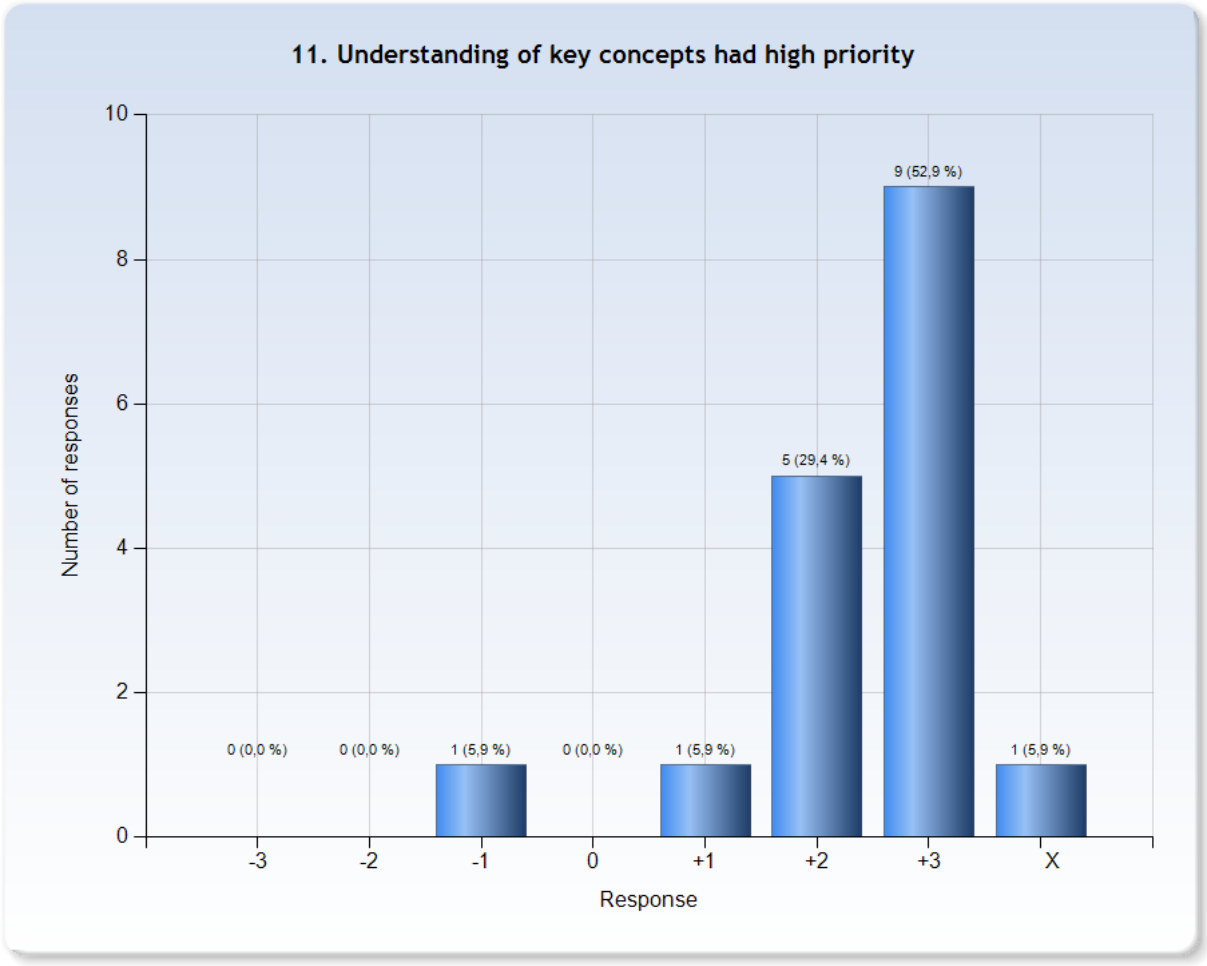


Comments

Comments (My response was: 0)
Totally valid for the lecture, not valid at all for the exercise.

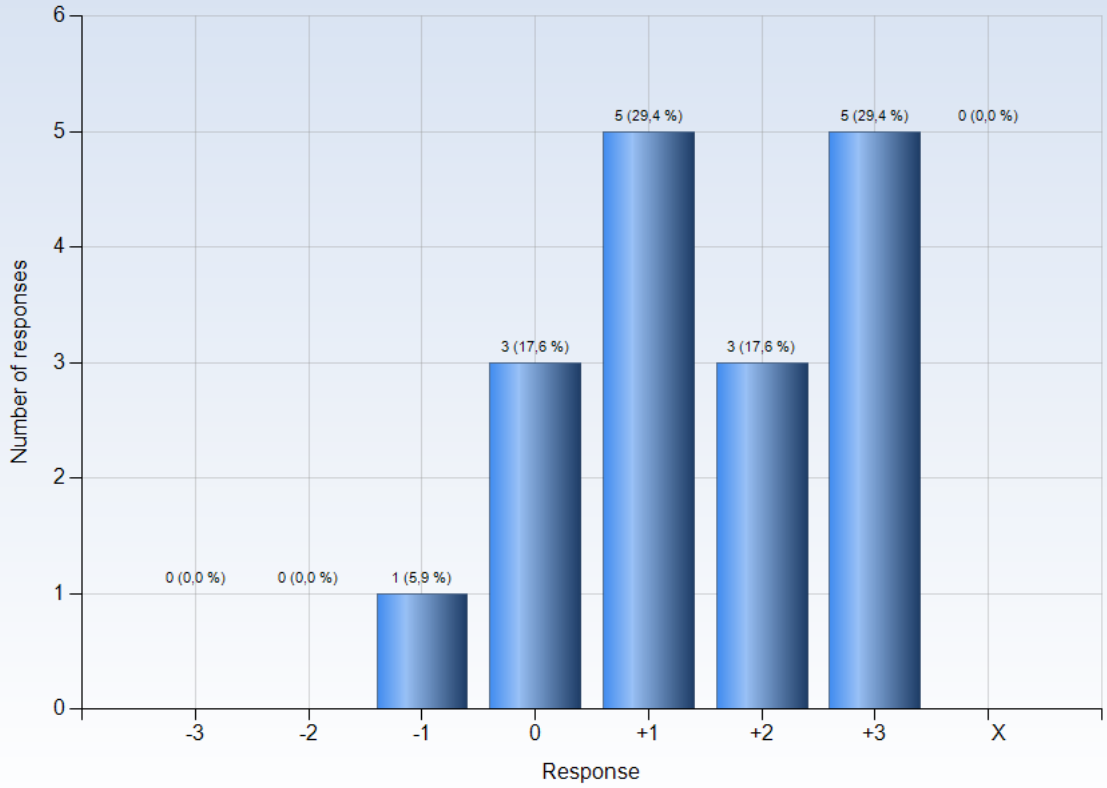

10. I was able to learn from concrete examples that I could relate to
Number of responses
10
8
6
4
2
0
0 (0,0 %)
0 (0,0 %)
1 (5,9 %)
1 (5,9 %)
2 (11,8 %)
4 (23,5 %)
9 (52,9 %)
0 (0,0 %)
-3
-2
-1
0
+1
+2
+3
X
Response

Comments


11. Understanding of key concepts had high priority
Number of responses
10
8
6
4
2
0
0 (0,0 %)
0 (0,0 %)
1 (5,9 %)
0 (0,0 %)
1 (5,9 %)
5 (29,4 %)
9 (52,9 %)
1 (5,9 %)
-3
-2
-1
0
+1
+2
+3
X
Response

Comments

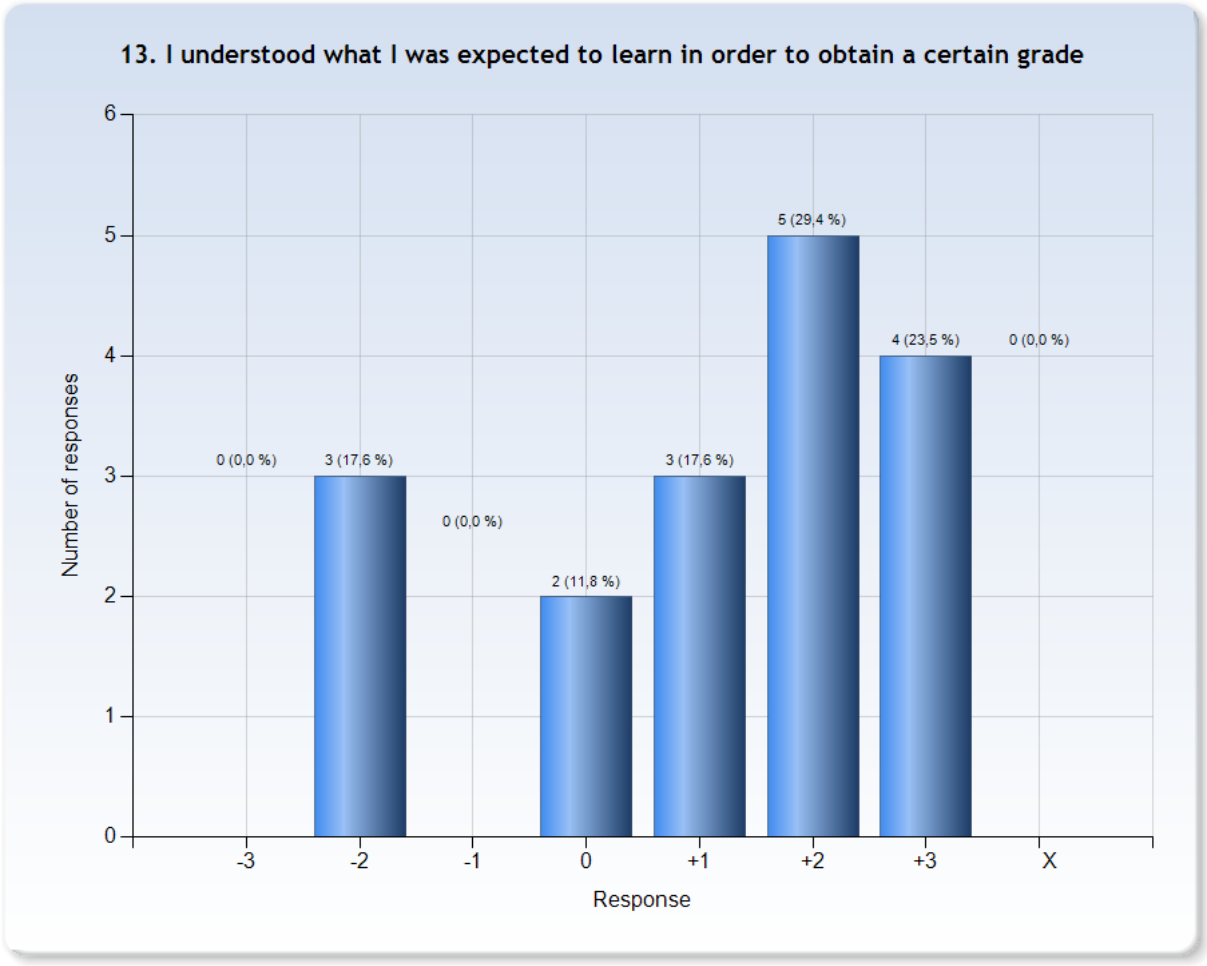
12. The course activities helped me to achieve the intended learning outcomes efficiently



Comments

(My response was: -1)

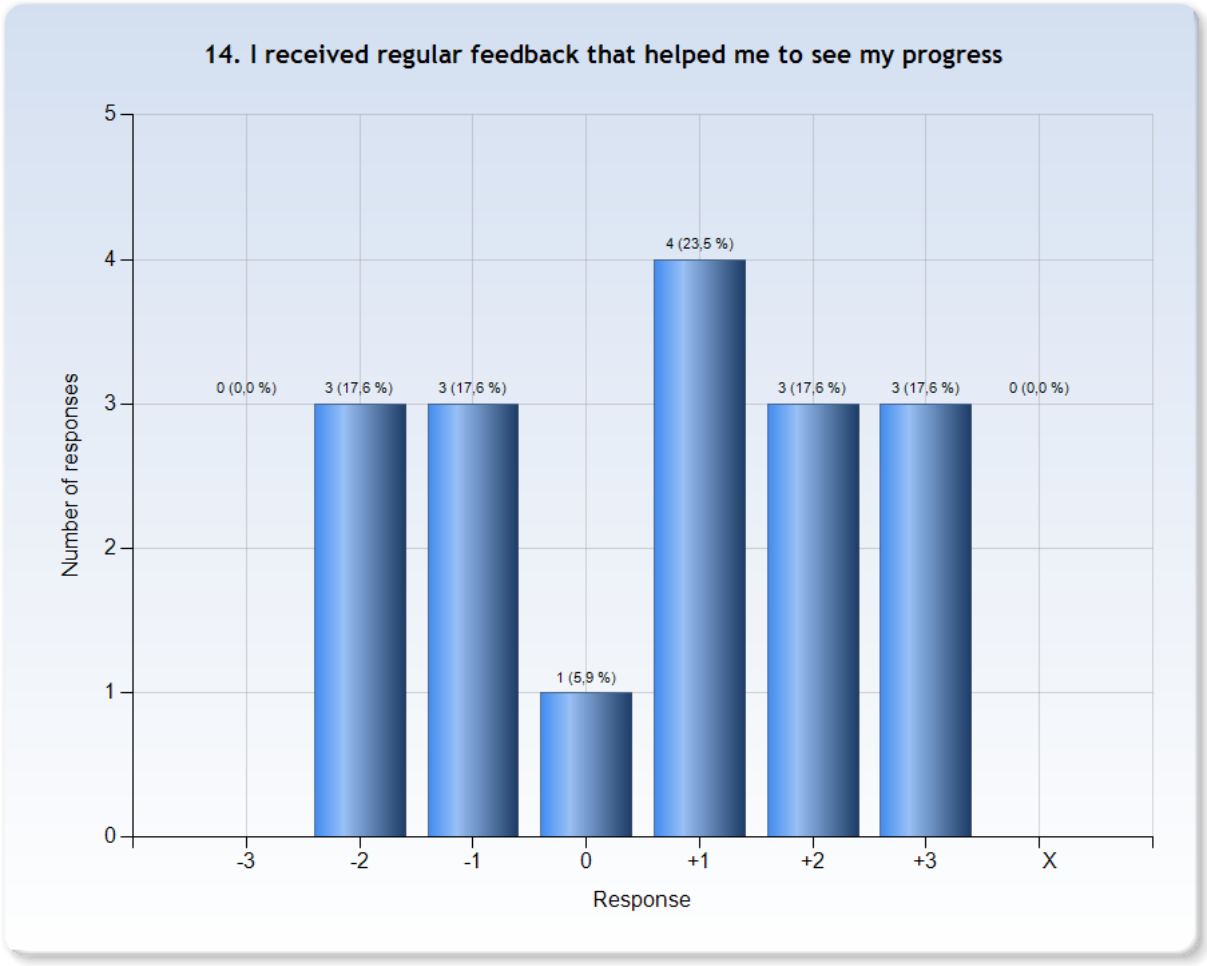
Not valid for the exercise.



Comments

Comments (My response was: -2)
It was not clear what to fulfill to get a specific good grade in the projects.

Comments (My response was: +1)
Sista uppgiften på projektet "analyze the situation for the company" var kanske lite väl öppen för tolkning

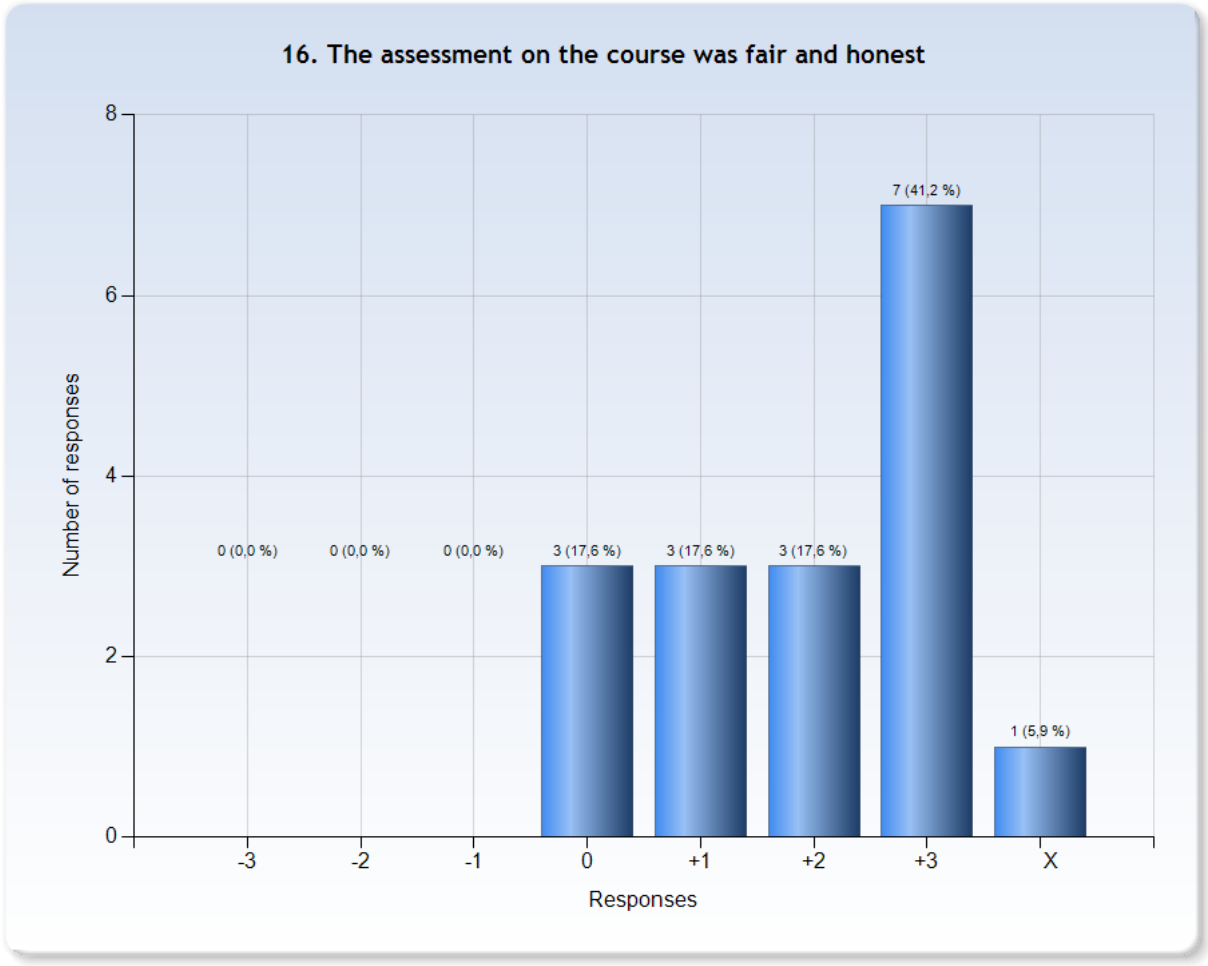


Comments

Comments (My response was: +3)
Grymt att projekten rättades så snabbt

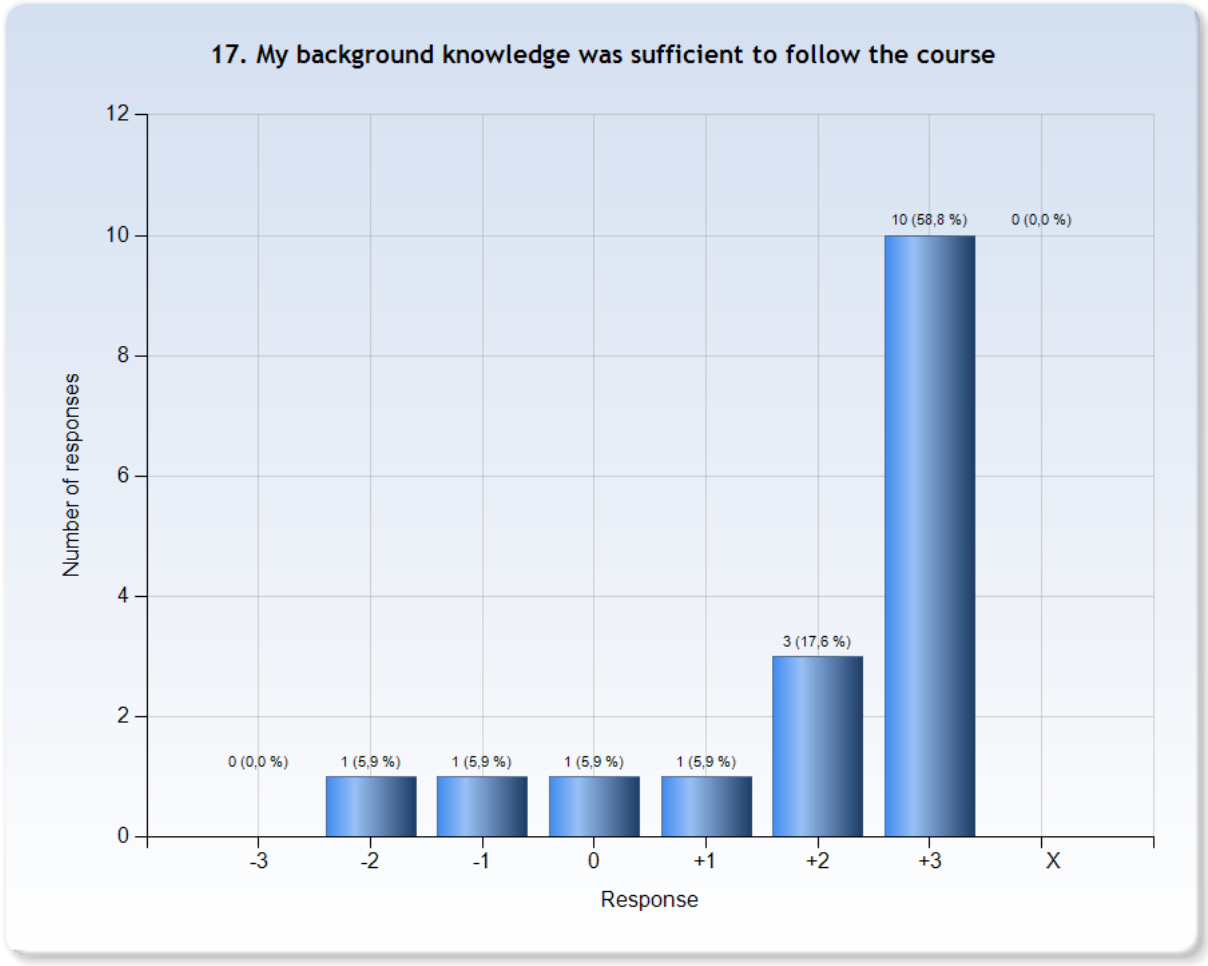

15. I could practice and receive feedback without being graded
Number of responses
Response
0
1
2
3
4
5
-3
-2
-1
0
+1
+2
+3
X
1 (5,9 %)
0 (0,0 %)
2 (11,8 %)
3 (17,6 %)
3 (17,6 %)
4 (23,5 %)
3 (17,6 %)
1 (5,9 %)

Comments

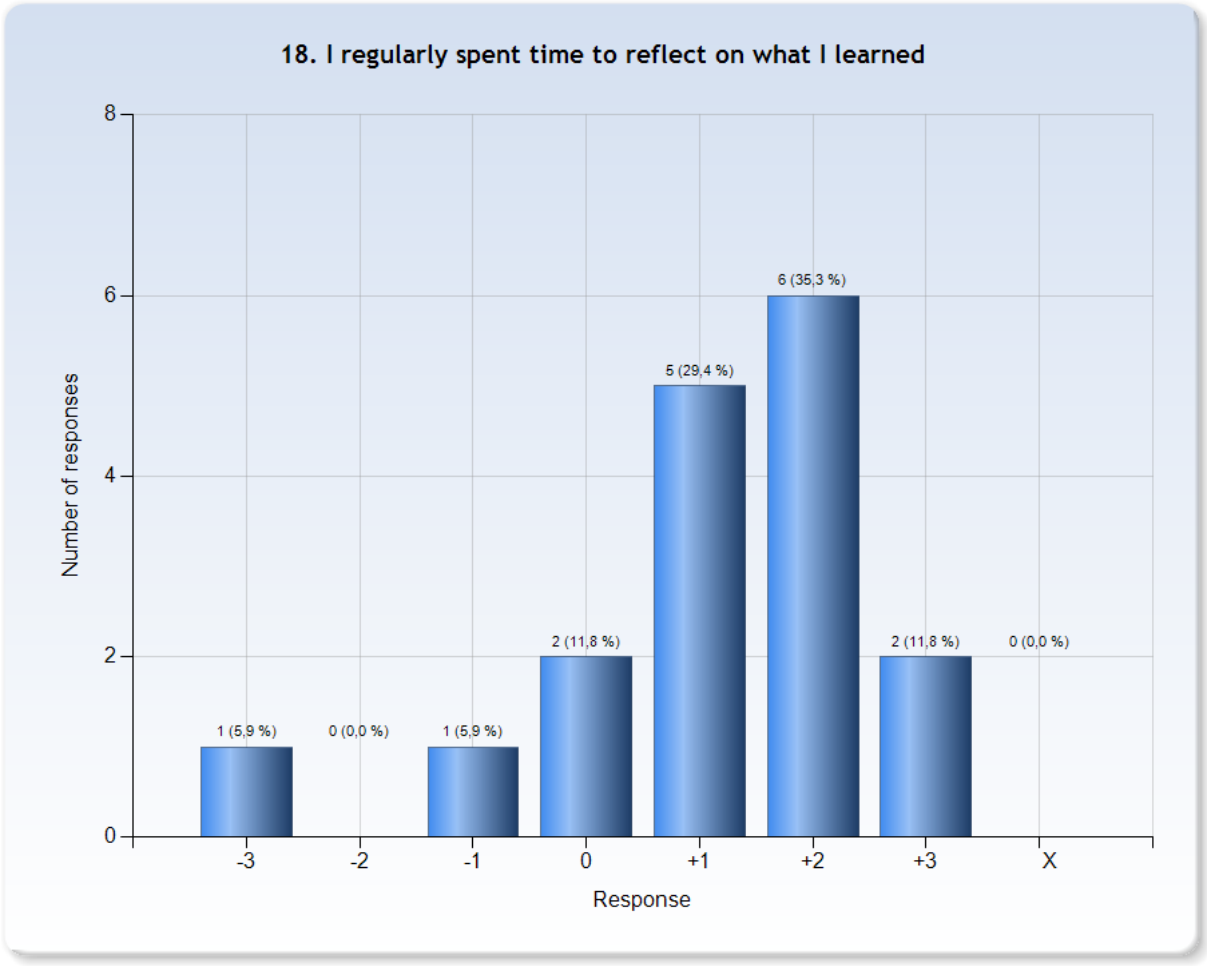


Comments

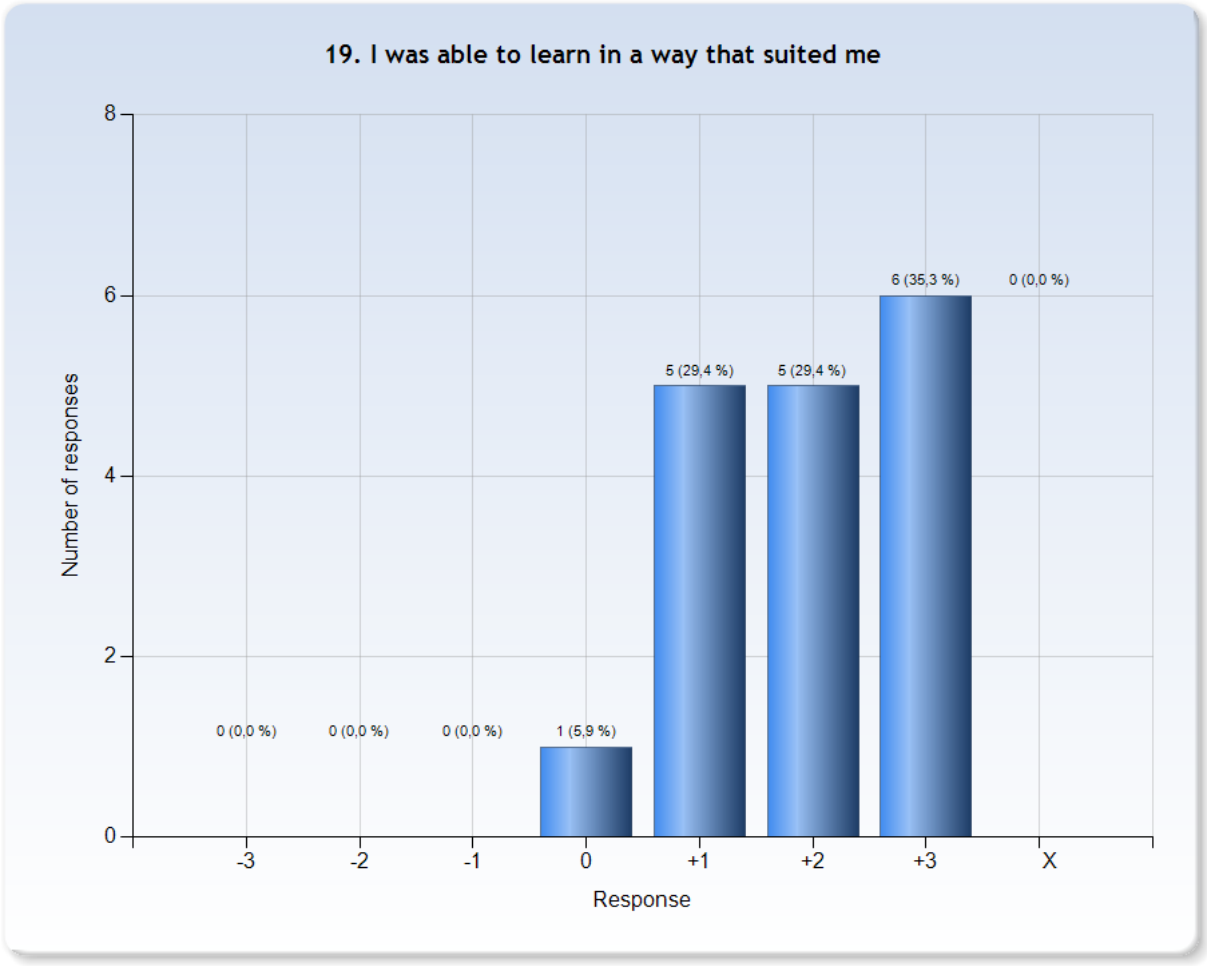
Comments (My response was: 0)
Folk gör inte alls lika mycket på projekten


17. My background knowledge was sufficient to follow the course
Number of responses
Response
0 (0,0 %)
1 (5,9 %)
1 (5,9 %)
1 (5,9 %)
1 (5,9 %)
3 (17,6 %)
10 (58,8 %)
0 (0,0 %)
-3
-2
-1
0
+1
+2
+3
X

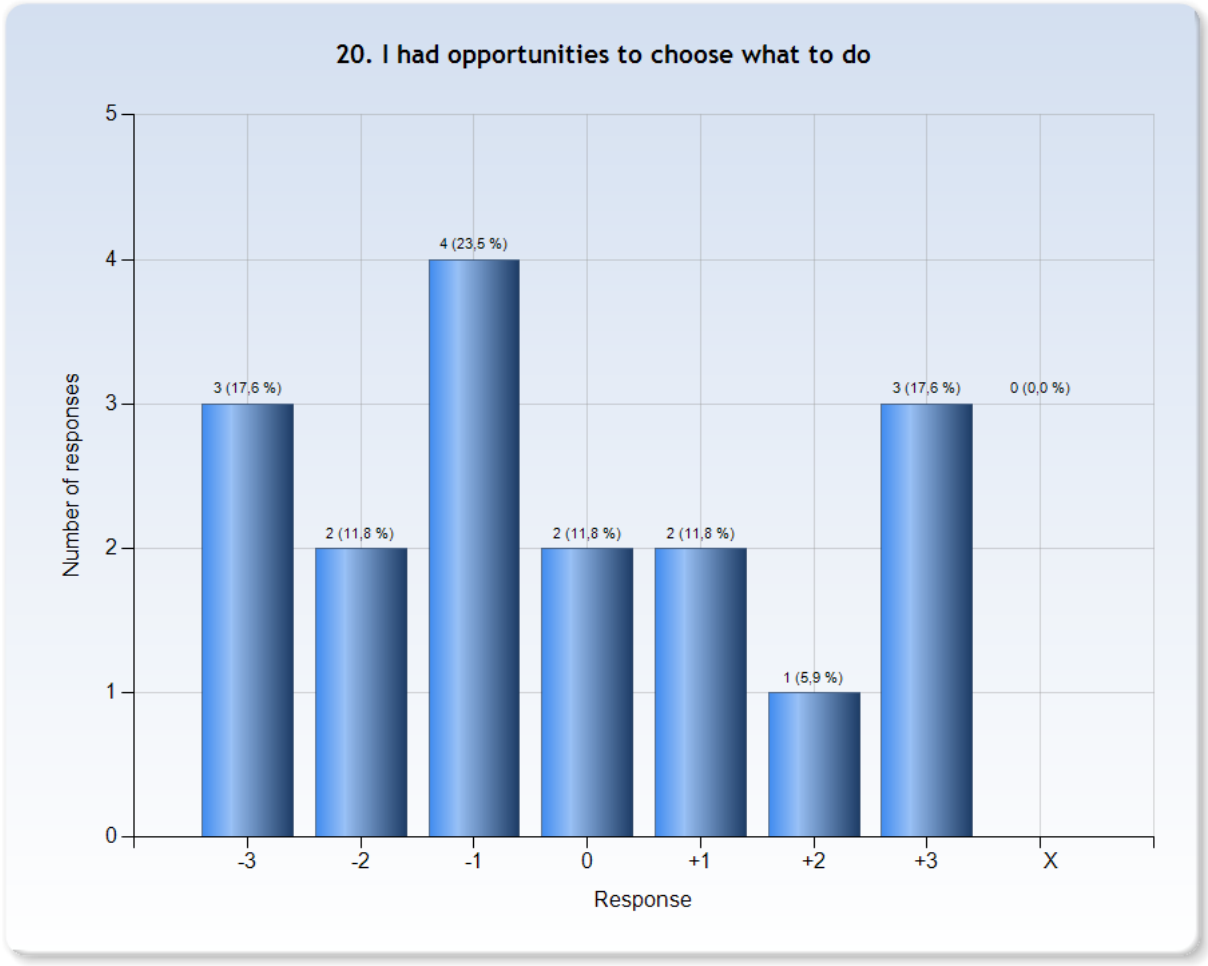
Comments


18. I regularly spent time to reflect on what I learned
Number of responses
Response
8
6
4
2
0
1 (5,9 %)
0 (0,0 %)
1 (5,9 %)
2 (11,8 %)
5 (29,4 %)
6 (35,3 %)
2 (11,8 %)
0 (0,0 %)
-3
-2
-1
0
+1
+2
+3
X

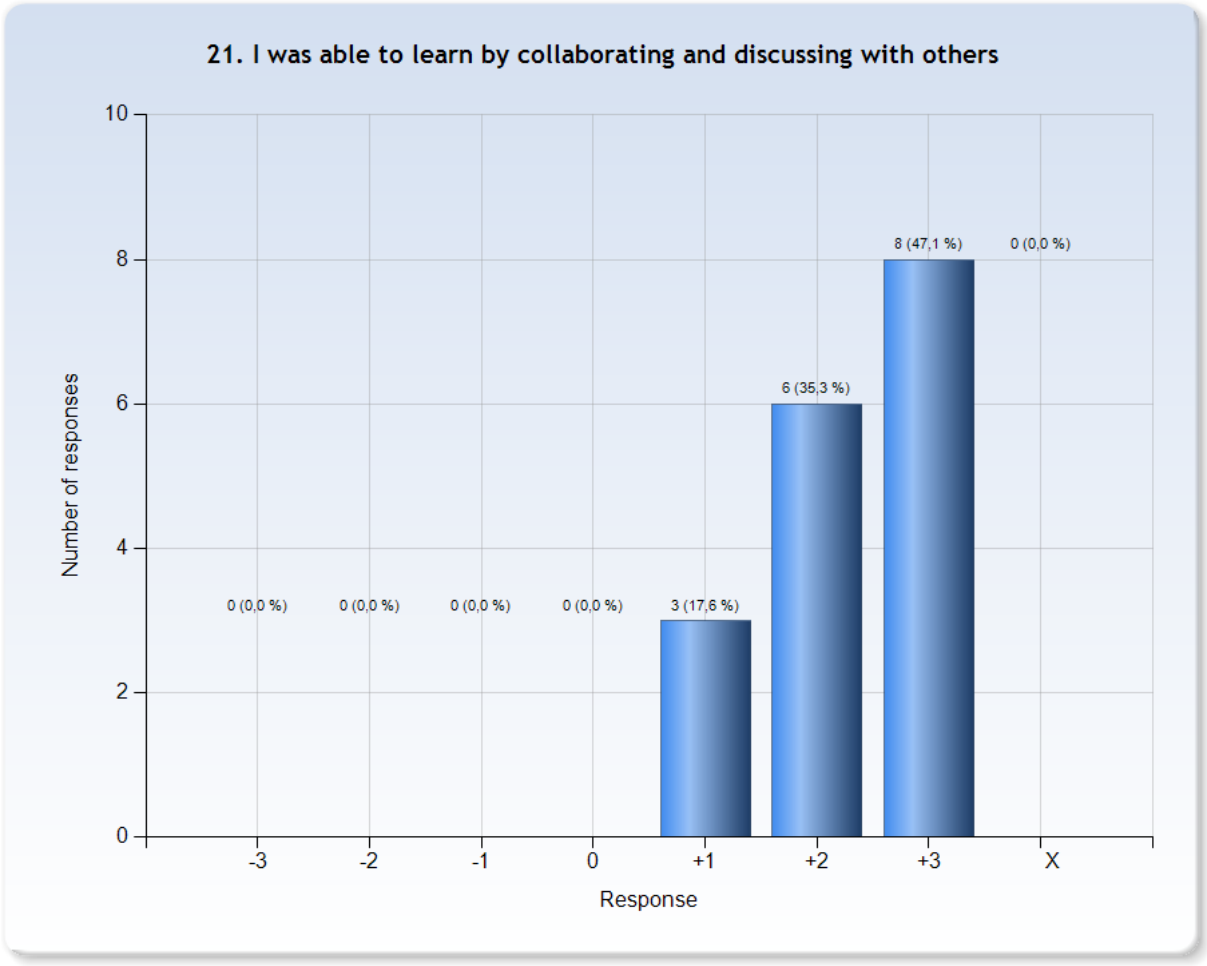
Comments


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 %)
0 (0,0 %)
1 (5,9 %)
5 (29,4 %)
5 (29,4 %)
6 (35,3 %)
0 (0,0 %)

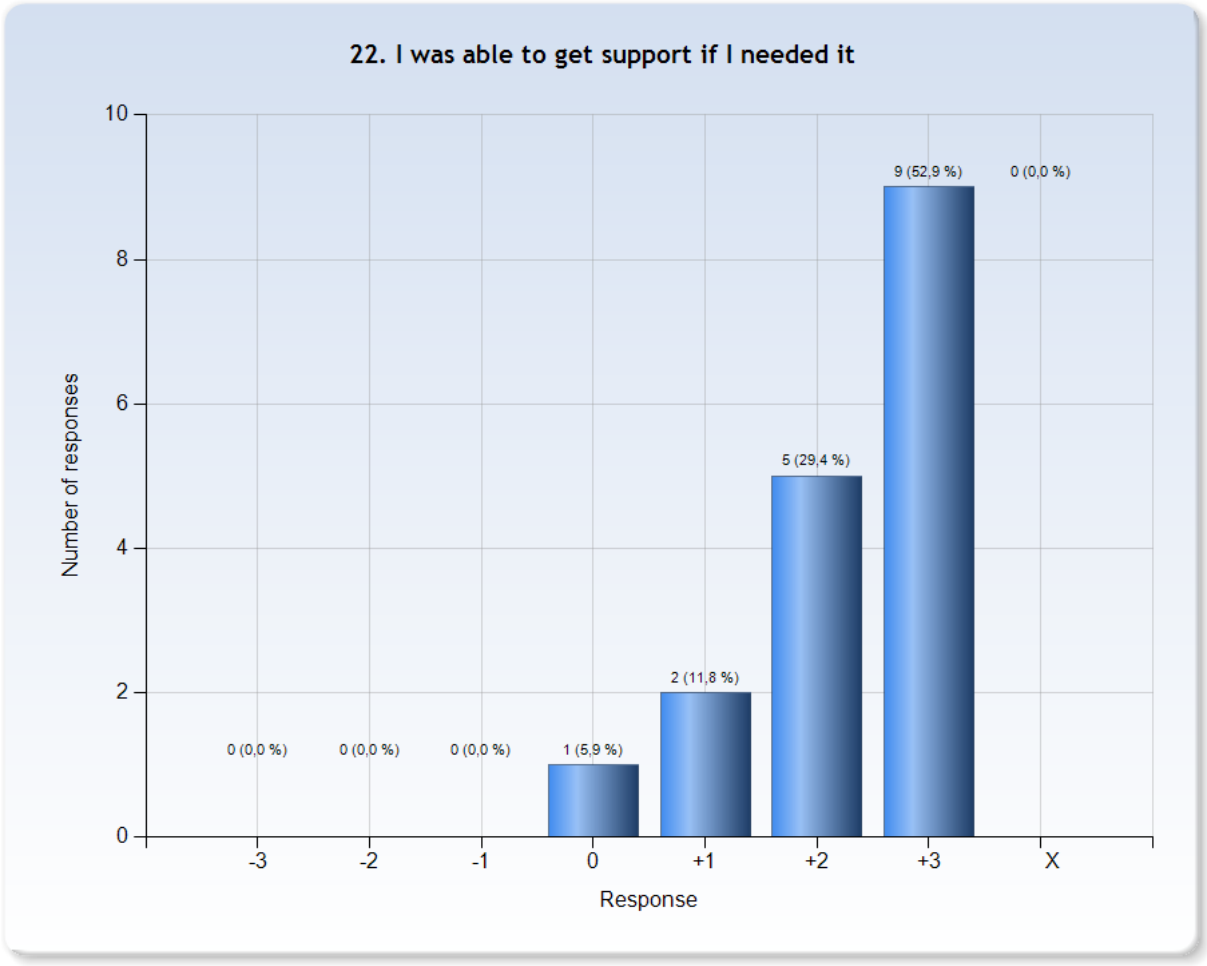
Comments


20. I had opportunities to choose what to do
Number of responses
Response
0
1
2
3
4
5
-3
-2
-1
0
+1
+2
+3
X
3 (17,6 %)
2 (11,8 %)
4 (23,5 %)
2 (11,8 %)
2 (11,8 %)
1 (5,9 %)
3 (17,6 %)
0 (0,0 %)

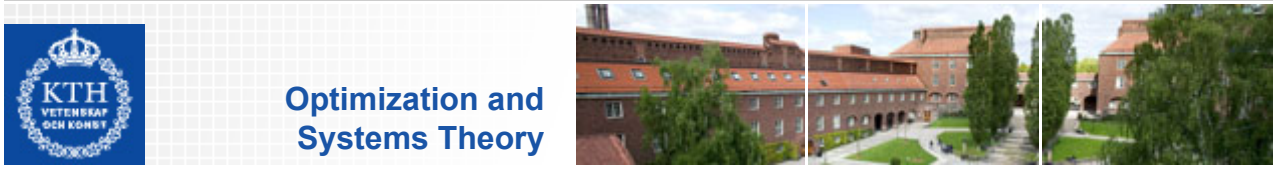
Comments


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 %)
0 (0,0 %)
3 (17,6 %)
6 (35,3 %)
8 (47,1 %)
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
0
2
4
6
8
10
-3
-2
-1
0
+1
+2
+3
X
0 (0,0 %)
0 (0,0 %)
0 (0,0 %)
1 (5,9 %)
2 (11,8 %)
5 (29,4 %)
9 (52,9 %)
0 (0,0 %)

Comments



Optimization and Systems Theory

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SF2812 Applied Linear Optimization, 7.5hp

The course is given in period 3, spring 2017.

- Official course information

Examiner and instructor: Anders Forsgren
Exercise leader and project leader: David Ek

- Course information
- KTH course web page
- Information on how to register for the exam can be found here.
- Information on exam placement can be found here.
- GAMS at the KTH linux computers.
  - Type "module add gams" or add it to a suitable login file.
  - Use an editor, for example emacs, to create/modify model files (".gms") and reading output files (".lst").
  - Put the model files in your home catalog. Run GAMS from that catalog, e.g. "gams trans1".
  - Please note that there is a whole library of example files at GAMS subdirectory "modlib".
- GAMS on your own computer.
  - The demo version of GAMS (which we use) can be downloaded from the GAMS website.
- GAMS resources
  - GAMS documentation
  - GAMS user's guide
- To solve larger problems than what the demo version of GAMS can handle.
  - There is an option to solve optimization problems over the internet by NEOS (http://www.neos-server.org/). Here you can send for example GAMS files and obtain access to various solvers without the size limitations of the demo version. This is a very useful tool. We recommend the solvers Gurobi, MOSEK or Xpress-MP for solving LP models as well as MIP models on NEOS.
  - NEOS is usually reliable, but please note that you will not be allowed to hand in late because of possibly waiting for answer from NEOS. Please do not wait to the last moment with submitting jobs.
- Exams
  - Final exam June 7 2017 (pdf)
    Solutions to final exam June 7 2017 (pdf)
  - Final exam March 13 2017 (pdf)
    Solutions to final exam March 13 2017 (pdf)
  - Final exam June 8 2016 (pdf)
    Solutions to final exam June 8 2016 (pdf)
  - Final exam March 17 2016 (pdf)

Solutions to final exam March 17 2016 (pdf)
- Final exam June 10 2015 (pdf)
  Solutions to final exam June 10 2015 (pdf)
- Final exam March 18 2015 (pdf)
  Solutions to final exam March 18 2015 (pdf)
- Final exam May 22 2014 (pdf)
  Solutions to final exam May 22 2014 (pdf)
- Final exam March 17 2014 (pdf)
  Solutions to final exam March 17 2014 (pdf)
- Final exam January 10 2013 (pdf)
  Solutions to final exam January 10 2013 (pdf)
- Final exam October 18 2012 (pdf)
  Solutions to final exam October 18 2012 (pdf)
- Final exam February 18 2012 (pdf)
  Solutions to final exam February 18 2012 (pdf)
- Final exam October 20 2011 (pdf)
  Solutions to final exam October 20 2011 (pdf)
- Final exam January 13 2011 (pdf)
  Solutions to final exam January 13 2011 (pdf)
- Final exam October 21 2010 (pdf)
  Solutions to final exam October 21 2010 (pdf)
- Final exam January 15 2010 (pdf)
  Solutions to final exam January 15 2010 (pdf)
- Final exam October 19 2009 (pdf)
  Solutions to final exam October 19 2009 (pdf)
- Final exam January 9 2009 (pdf)
  Solutions to final exam January 9 2009 (pdf)
- Final exam October 20 2008 (pdf)
  Solutions to final exam October 20 2008 (pdf)
- Final exam January 16 2008 (pdf)
  Solutions to final exam January 16 2008 (pdf)
- Final exam October 23 2007 (pdf)
  Solutions to final exam October 23 2007 (pdf)

- Course analysis after the course given in the spring of 2016

Published by: Optimization and Systems Theory, KTH
Anders Forsgren, andersf@kth.se
Last updated: 2017-06-07

Optimization and Systems Theory

SF2812 Applied Linear Optimization, 7.5hp, 2016/2017

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, 2016/2017***. Available via Canvas.
- ***Lecture notes in applied linear optimization, 2016/2017***. May be downloaded from this web page, see the schedule below. Also available via Canvas.
- ***Supplementary course material in applied linear optimization, 2016/2017***. Available via Canvas.
- ***Theory questions in applied linear optimization, 2016/2017***. Available via Canvas.
- ***GAMS, A user's guide***. May be downloaded from 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 2 and February 16 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 16, and presence at the following dicussion session.
- Pass project assignment 2, with presence at the compulsory presentation lecture on Thursday March 2 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. 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. 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 13 2016, 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 17	15-17	L52	Introduction. Linear programming models. (pdf)
L2.	Thu	Jan 19	8-10	L51	Linear programming. Geometry. (pdf)
L3.	Fri	Jan 20	13-15	L51	Lagrangian relaxation. Duality. LP optimality. (pdf)
L4.	Tue	Jan 24	15-17	L52	Linear programming. The simplex method. (pdf)
E1.	Thu	Jan 26	8-10	L51	Linear programming. The simplex method.
L5.	Fri	Jan 27	13-15	L52	More on the simplex method. (pdf)
E2.	Tue	Jan 31	15-17	L51	Linear programming. The simplex method.
P1.	Wed	Feb 1	10-12	V34	Introduction to GAMS. (pdf)
P2.	Thu	Feb 2	8-10	Brun	GAMS excercise session.
L6.	Fri	Feb 3	8-10	V34	Stochastic programming. (pdf)
E3.	Tue	Feb 7	15-17	L51	Stochastic programming.
L7.	Thu	Feb 9	8-10	L51	Interior methods for linear programming. (pdf)
E4.	Fre	Feb 10	8-10	E2	Interior methods for linear programming.
L8.	Tue	Feb 14	15-17	L52	Integer programming models. (pdf)
L9.	Wed	Feb 15	10-12	V34	Branch-and-bound. (pdf)
P3.	Thu	Feb 16	8-10	L41, L52	Presentation of project assignment 1.
E5.	Fri	Feb 17	8-10	L52	Integer programming.
L10.	Tue	Feb 21	15-17	Q34	Decomposition and column generation. (pdf)
E6.	Thu	Feb 23	8-10	Q31	Decomposition and column generation.
L11.	Fri	Feb 24	8-10	E2	Lagrangian relaxation. Duality. (pdf)
E7.	Tue	Feb 28	15-17	L52	Lagrangian relaxation. Duality.
P4.	Thu	Mar 2	8-10	V12, V32	Presentation of project assignment 2.
L12.	Fri	Mar 3	8-10	E2	Subgradient methods. (pdf)
E8.	Mon	Mar 6	10-12	L51	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/.

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