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# Kursanalys: EL2700

## Period 1, HT 2021.

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Detta är en kursanalys för EL2700, Modell-prediktiv reglering för period 1, 2021.

Vi har gjort en kursenkätundersökning som besvarades av 23 av 51 personer. Svaren från denna undersökning ligger som bilaga till den här kursanalysen.

Överlag var studenterna nöjda eller mycket nöjda med kursen. Vi jobbar kontinuerligt med kursutveckling, och förbättrar materialet baserat på studenternas feedback och våra egna erfarenheter. Detta verkar ha gett goda resultat.

Fastän att vi planerade att ge kursen som "flipped classroom" och dela upp kursen i två grupper med två föreläsningstimmar per vecka, så bad studenterna att vi skulle boka stora salar ("det är ju ändå tomt på KTH") och köra fyra timmar föreläsningar i helklass per vecka. Så det gjorde vi.

Utöver detta så lät vi de mini-videos som spelades in under första pandemiåret ligga kvar på Canvas, och på samma sätt lät vi videomaterialet för övningarna ligga kvar. Detta uppskattades av de elever som inte ville eller kunde delta på föreläsningarna.

I år hade vi ett nytt designprojekt om rymdrobotik i kursen. Elevernas slutdesigner presenterades som en tävling, och vi hade en gästföreläsare från NASA uppkopplad via zoom för att titta på de vinnande bidragen. Detta var mycket uppskattat av eleverna.

Tentamen gavs i sal, vilket också hade efterfrågats av eleverna.

Kursens assistenter har som vanligt gjort ett fantastiskt jobb, och det får också mycket goda vitsord för detta i kursanalysen.

Kursnämnden bestod av Victor Sanchez. Ytterligare en person anmälde sig till kursnämnden men dök inte upp på mötena. Vi hade konstruktiva och intressanta diskussioner under vårt kursnämndsmöte.

Tentamen gick bra från ett "genomströmningsperspektiv". Av 45 skrivande så blev 40 godkända. Däremot så var det bara två elever som fick betyget A. Detta är lågt , och vi tror att detta kan ha berott på att eleverna lagt för mycket tid på projektet och för lite tid på teori och räkneuppgifter, men vi måste undersöka detta närmre.

Betyg	Antal tentander
A	2
B	6
C	10
D	16
E	5
Fx	1
F	5

Inför nästa år kommer vi framförallt att arbeta med att förbättra föreläsningskompendiet och övningshäftet.

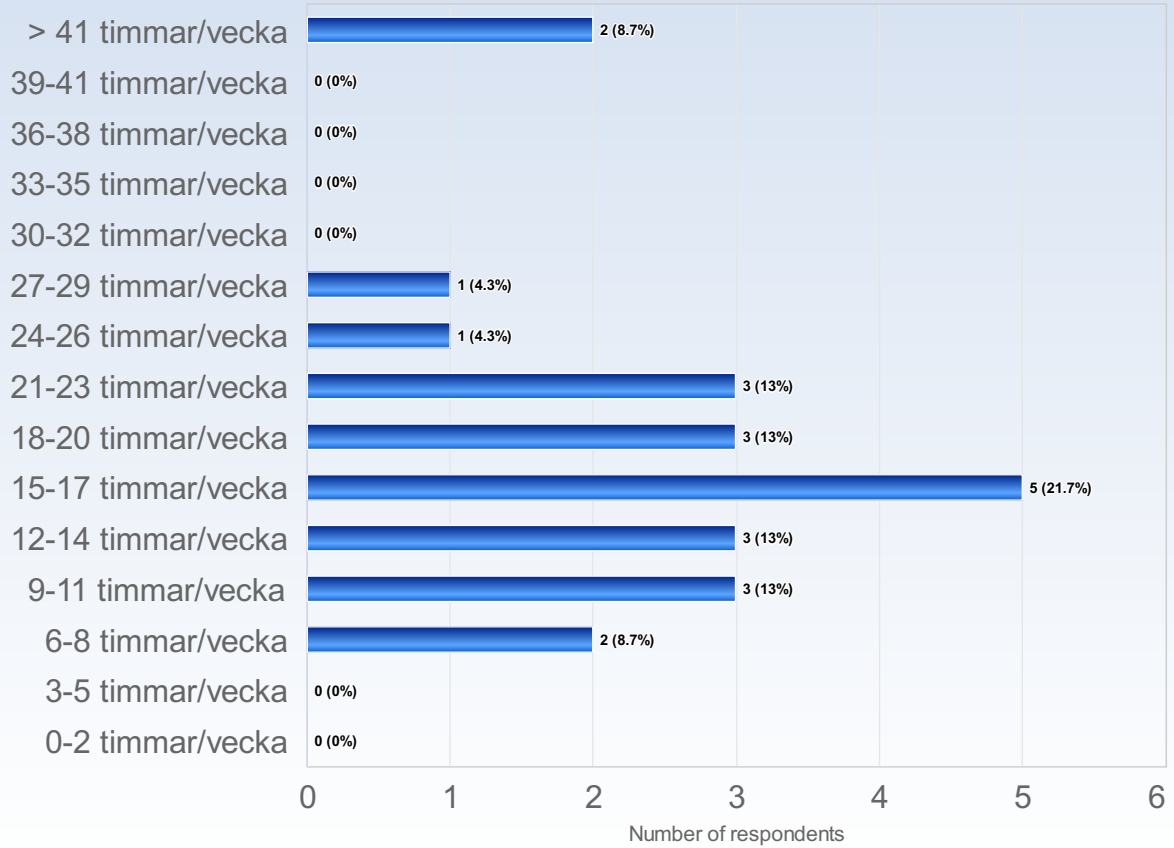
Mikael Johansson

# EL2700 - 2021-11-01

Antal respondenter: 51  
Antal svar: 23  
Svarsfrekvens: 45,10 %

## ESTIMATED WORKLOAD

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



## Comments

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

Very meaningful and useful course! But a little complicated and difficult for me to understand the course.  
The course was intensive.

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

The average time of work was nice because everything was well explained  
good to reduce the size of labs from last year.

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

It's good for this course, sometimes more hours were needed but overall it works well for a 7.5 hp course. I had several other courses which made it stressful but in isolation I think the workload was good.

I think it is ok for a 7.5 credit course.

Though every week we will have programming assignment to do, the assignment was really well organized and helped a lot to understand key concept, which makes it worthwhile to spend more time on this course .

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

To be able to attend the lectures (4 hours / week), exercise session (2 hours / week), assignments (4 hours / week) and then keep up with the recommended exercises and then in the end study for the exam, one had to spend easily 18-20 hours a week on the course.

The workload was quite high, much material to cover and take in.

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### Comments (I worked: 21-23 timmar/vecka)

As I have almost no background knowledge, the course is pretty challenging for me. But after finishing the course, I have learned a lot of useful knowledge about system dynamics and control. In my opinion, it might be the hardest course for me in the past several years. However, with the help of the professor and TA, I learned more than in any other course.

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### Comments (I worked: 27-29 timmar/vecka)

This is a challenging course by its own right- for me it took a lot of time with the assignments, often having issues with syntax and such issues. The amount of effort put down on the course was easy to motivate though because the course was interesting and Mikael kept it interesting the whole time. I do think that the amount of effort put on the course was high but I am not sure that it was directed towards what was needed to be learned in the course but rather, much of the time was spent on practical stuff regarding just getting the assignments working on my computer and with the syntax which was quite annoying.

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### Comments (I worked: > 41 timmar/vecka)

It's a demanding course atleast for me maybe because I was new to most of optimization techniques taught.

This course was very theoretical and mathematical proof heavy, so it was hard to understand what was important or not. Took a lot of self-studying to to understand the material thoroughly.

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# LEARNING EXPERIENCE

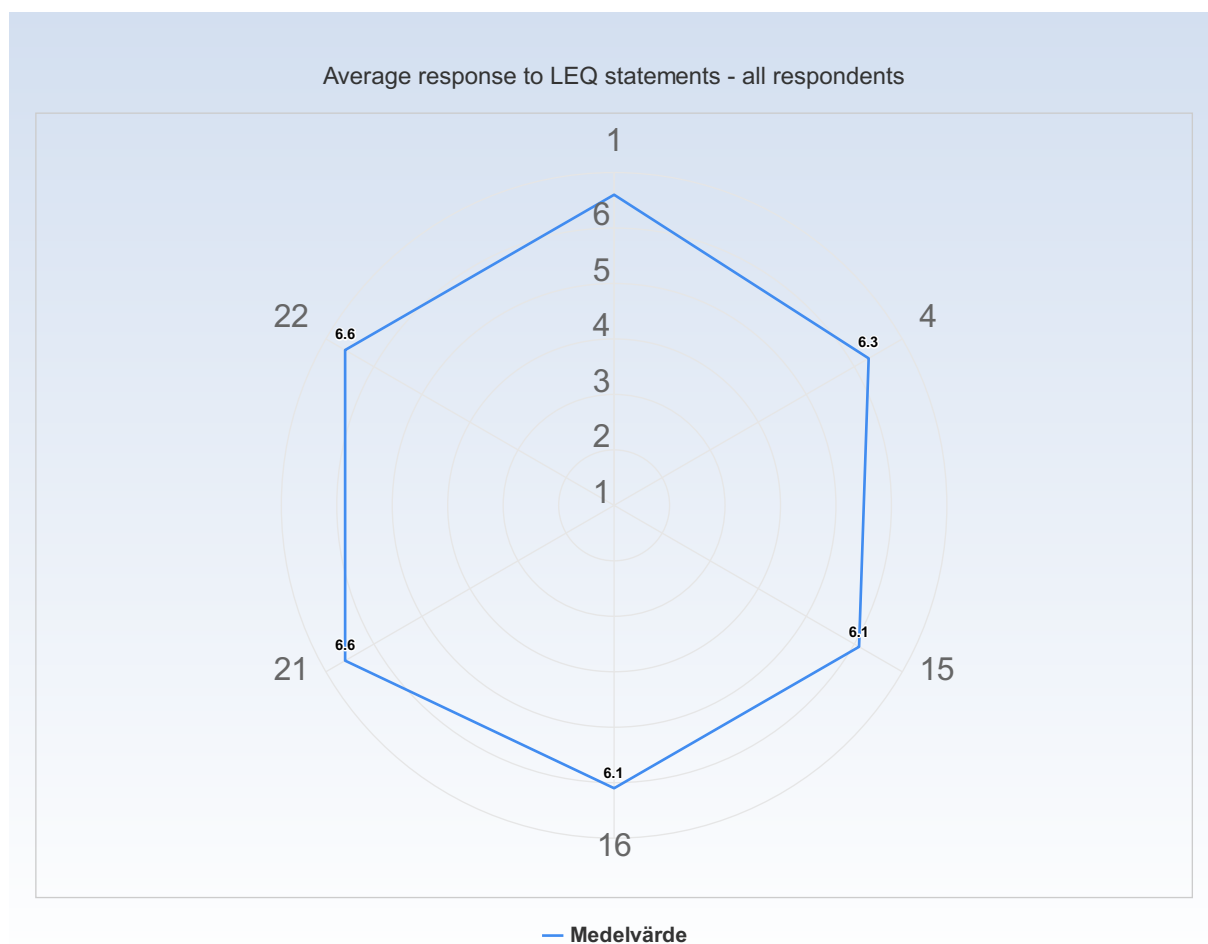
The polar diagrams below show the average response to the LEQ statements for different groups of respondents (only valid responses are included). The scale that is used in the diagrams is defined by:

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.

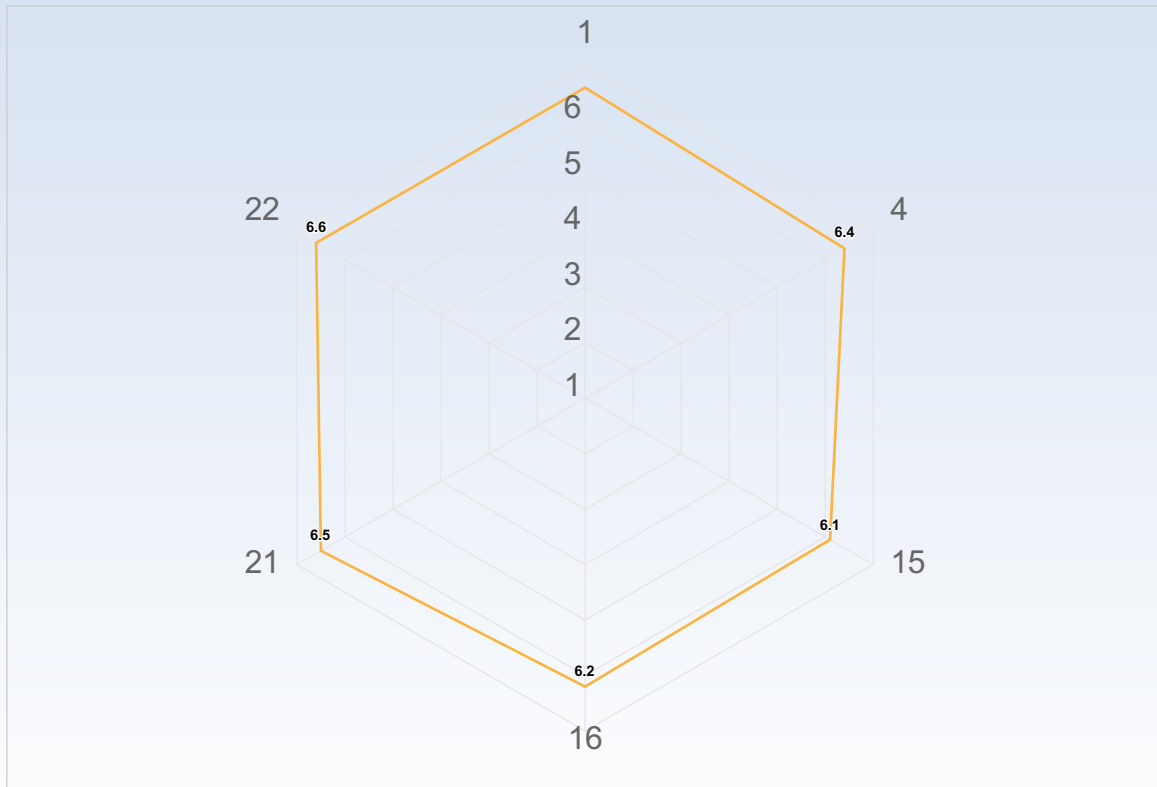
Biggs J. & Tang, C. (2011). *Teaching for Quality Learning at University*, Chapter 6, pp. 95-110. Maidenhead: McGraw Hill.

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.

Average response to LEQ statements - per gender



— Kvinna — Man — Annat — Vill ej uppge

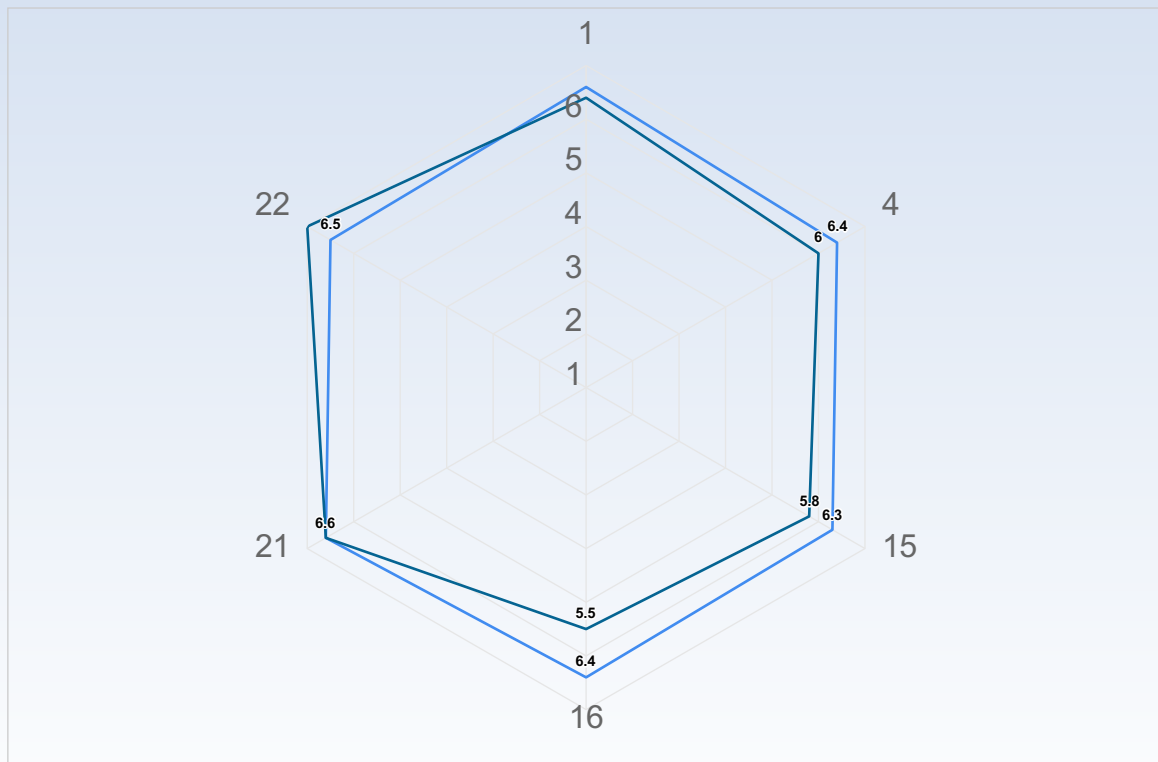
Comments

Comments (I am: Man)

Nil

It has many mathematical derivations.

Average response to LEQ statements - per type of student



— Internationell masterstudent — Internationell utbytesstudent — Svensk student i årskurs 1-3  
 — Svensk student i årskurs 4-5 — Annan typ av student — Vill ej uppge

Comments

Comments (I am: Internationell masterstudent)

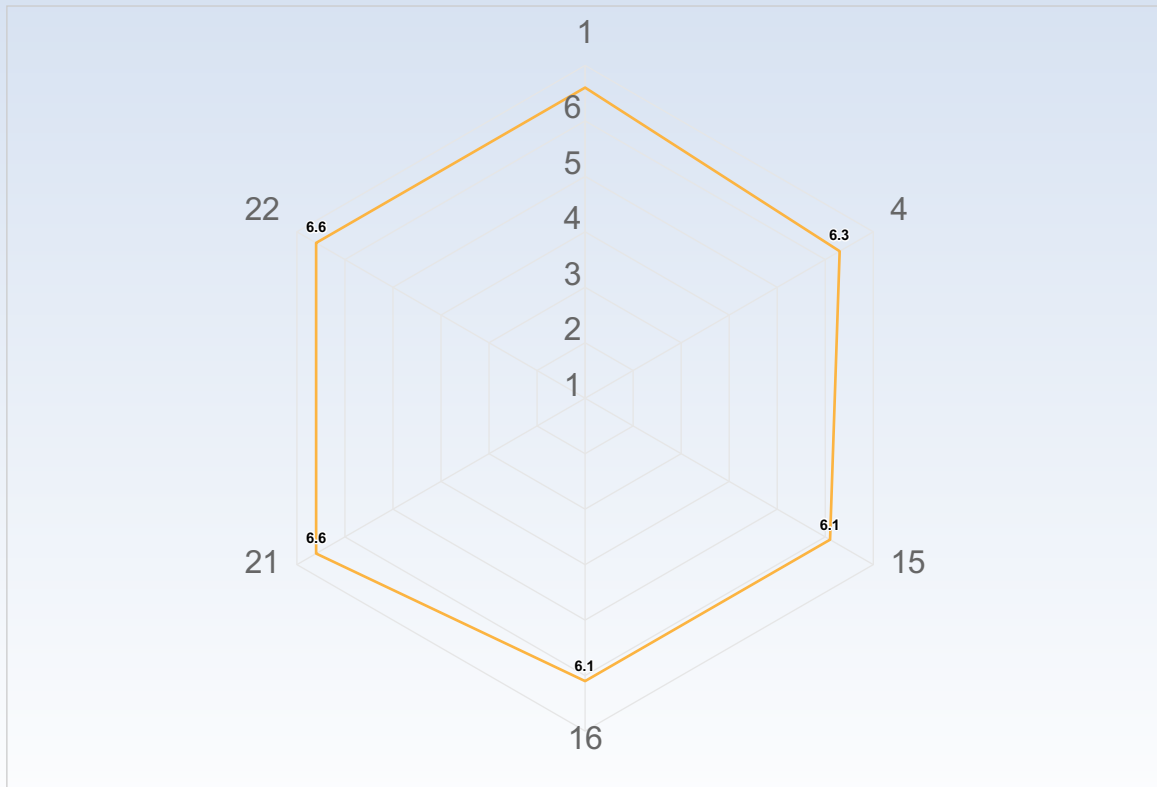
Nil

The course was fine from an international perspective. I didn't have any issue understanding the professor or TA's.  
 As an international student, we first need to be familiar with the academic term.

Comments (I am: Svensk student i årskurs 4-5)

I go TELPM/Elkraft and it was quite busy with other courses in parallel but it was good.

Average response to LEQ statements - per disability



— Ja — Nej — Vill ej uppge

# GENERAL QUESTIONS

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What was the best aspect of the course?

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

The course was well-structured, and the lab work was very interesting.

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

The weekly mail of what we should focus on. It was really a good way to plan a personal schedule and to be able to work in harmony with the course.

The whole astrobee project + labs were nice, with a "practical" use of what we learned.

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

- Working on the Astrobee project and also attending the lectures simultaneously. Concepts learnt during the lectures were immediately applied in the project/assignment

The subject MPC in general and the timely help we could receive on Slack

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

The labs with Astrobee and the competition as well as a good structure and material on Canvas.

the project is really cool but maybe a little bit to time consuming.

Motivated lecturer

The lecture notes are well illustrated and the competition part of final project was super interesting

What was the best aspect of the course? (I worked: 18-20 timmar/vecka)

When we got into LQR and then MPC.

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

The assignments and that you could get help easily!

The choice of MPC topic is very interesting.

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

The course was well structured and all of the members of the course the professor and the TA were there to help at all times. The assignments were defined so as to help us understand the topic of the current week.

What was the best aspect of the course? (I worked: 27-29 timmar/vecka)

The best aspect of the course was the lectures with Mikael and the course material. I think the lecture notes/book is one of the best books we've gotten during my time at KTH, together with the course book with Glader & Ljung for EL1120.

Mikael always kept the course interesting and engaging. It felt like he had a good pedagogical structure with exit tickets, asking questions and keeping us on the toe all the time. that was Positive. Pedro and the the other guys was also always helpful and great to talk to.

What was the best aspect of the course? (I worked: > 41 timmar/vecka)

It is one of the most well structured course I have studied so far. Though course in it's core itself is tough, it is interesting enough to work especially if we love controls.

The material was interesting and its use in the real-world was understood.



## What would you suggest to improve?

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

Maybe do everything on Python or on Matlab or show both version every time. But not a hybrid version because we easily get lost.

The course is too theoretical according to me, could use less formal proofs on lectures and more actual calculating examples on the board.

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

- The course activities could be reduced.

- The assignments, project, labs, paper presentation and the exam felt too heavy. The paper presentation could be avoided. Rather than having a 5 hr exam, there could be a quiz to test the concepts the student has learnt. Since MPC is actually computing over long horizons using software, doing calculations in the exam seemed pointless.

- Suggestion: A quiz instead of exam which focuses on the concepts like one of the questions in the exam.

The assignments can really improve. The learning from assignments was quite minimal because all that we had to do was plug in few lines of code within an ocean, which used to, more often than not, take way too much time than necessary because maximum time was just spent on figuring out the code. (And for those new to Python, it use to take really long).

Instead it would be nicer if students are given smaller tasks wherein they implement an entire optimization problem by themselves. Starting with something small (not as complex as astrobe), we can add functionality to the code with subsequent assignments. It could even be a small spring-mass system, but students do the entire code, which would help learn a lot more.

### What would you suggest to improve? (I worked: 15-17 timmar/vecka)

- focus on one programming language

- correction of the assignment should be done faster, we got the correction of assignment 2 4 weeks after we have submitted it and then we should correct something in the most stressful week of the course with a time limit of one week.

- too much workload in the last week (project, presentation and start of learning for exam). I had also assignments for other courses.

More geometrical intuition about invariant sets can be offered in lecture, this part is a little bit hard to understand when only reading lecture notes

### What would you suggest to improve? (I worked: 18-20 timmar/vecka)

To quicker get to LQR and MPC, this way we could spend more time on the "real" parts of the course, i.e., the parts we most probably are going to use in the future. Though I get the layout of the course, to explain the underlying theory that ends up in MPC, but if the course simply is called MPC, I also think that it should focus more on that. Otherwise with this layout I think that the course should be 15 points and spread out to 2 periods. This way you could spend the first period on building the solid foundation I believe you intended for us to get, then the second period we could get spend more time on applying LQR and MPC and learning how to tune it and use it.

And the exam; Once again, if the course is about MPC then I also think that the exam should be pass/fail and consist of the underlying parts to MPC, then have a bigger final project that is graded A-F.

### What would you suggest to improve? (I worked: 21-23 timmar/vecka)

How you explained MPC, it was really difficult at first to understand how everything came together. I also felt like there were a bit too many proofs as I kind of got lost of what we were actually doing or how the concepts actually worked.

Sometimes I find some small typos and inconsistent use of symbols in lecture notes or slides. But they are under revision and getting better.

As I am not good at coding, it would be better if we have more coding classes.

### What would you suggest to improve? (I worked: 27-29 timmar/vecka)

Acknowledging that this is generally a quite hard topic to understand with a lot of abstract concepts and very "math heavy", There are some improvements to make from my perspective:

#### 1: The Assignments

-The assignments was fun, and competition was fun, however, I am not sure that they helped me understanding the course as much as I would want them to. I think this was a bit flawed and though so from the beginning of the course. The concepts in this course couples a lot if different "subjects" together, and there is a lot of craft in doing so. In the assignments, most of the craft in doing LQR, MPC or Optimal control was already done and handed to me in a bunch of functions. The functions was well written but however, I think that handing out a bunch of functions which is written in object oriented language is not super pedagogical and with most of the "craft" already completed it gets more into syntax fighting and just trial and error in tuning controllers rather than understanding the core concepts of LQR, MPC and so on. This gets also very apparent in combination with the article presentation which really gives the sensation of running before you are crawling.

On the opposite, the lab with the LP with the flight tickets and the QP problem with the chain was very good. There we got to do the "craft", i.e. set up constraints, build the Q-matrix and so forth.

My improvement suggestion is this:

- Crawling before running is always good praxis; Let the students do the "craft" in the assignments, maybe have the task less complex but let the students build the solution by them self. For example, for LQR, let the students find P using the Ricatti equation by hand for some system and Q & R, similar as in the exams, implement the LQR controller for some initial Q and R and then they can tune it. Let them implement some reference tracking by pen and paper and then implement in the mentioned LQR and so on. If the system is kept simple this should not take more time than the assignments. The CasADI master class problems is a good inspiration for this I think. Do this and keep the article presentation as this is good to widen the view on MPC. If you intend to keep the assignments, maybe let the articles be exchanged for some small project or whatever, just to include the crafting = )

-Python is nice and open source, but all students have access to Matlab and are used to it. There is good control toolboxes, good interface with CasADI (as with python) and you can use opti-stack and so on, but it is way easier to deal with vectors and dynamical systems without going through Numpy, so you can focus on the course and not on syntax or data errors.

#### 2: Exam time vs. exam questions

This is probably very individual but I think the amount of questions/work/calculations, especially for question 1 & 2 on the exam, was too much compared to the time we had. This gave very little time for problem 4 & 5 and at least I was not able to answer everything, not even close which is a first for me, and I did not get stuck. I think this exam could be extended to 6 hours if you want to include this amount of calculations in both 1 & 2. it wont cost you anything but the students will be able to answer everything and show you what they know, rather than stressing through. That or reduce the amount of calculations like the exams from 2017 with a brief answer question. Hard to be super objective with this but this is my opinion = ).

### What would you suggest to improve? (I worked: > 41 timmar/vecka)

I felt that this a big course to be squeezed in one period. If it is spanned over one semester with more involving assignments I felt it might be great. Because in the beginning we just need to insert missing lines in the assignments, if you can provide an opportunity for writing an script for MPC itself might be good. But it might be hard to get that further for students in one period (atleast for python beginners like me).

More figures, less theoretical and more applied use cases in MATLAB. the project should be simplified in a way that allows the students to derive more of the code (preferably in MATLAB or state that Python was a pre-requisite). Make the exam more like the book questions and/or previous exams.

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)

Study the course consistently.

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

Work regularly ! And don't hesitate to ask something on the slack, even if for you it's a dumb question.

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

- Study regularly and do the exercises at the right time. Doing the exercises at the end could lead to many doubts piling up close to the exam.

MPC is not difficult, the math might look complex but at the end of the day, it is quite logical. Moreover, the teaching staff do an excellent job of conveying concepts, through lectures and exercises.

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

Start from the beginning and make sure to get a feeling for system dynamics with Ax+Bu form and do tasks to get used to solving them.

Start early with the assignments

Attend the lectures and take exercise seriously

What advice would you like to give to future participants? (I worked: 18-20 timmar/vecka)

Use slack and communicate with the prof and TA's as much as you can.

What advice would you like to give to future participants? (I worked: 21-23 timmar/vecka)

The exam does not reflect the course really. (Not this years anyways)

It's a good course. If you are interested in controlling, choose it.

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

Follow the course everyday.

What advice would you like to give to future participants? (I worked: 27-29 timmar/vecka)

good course to take. Seems like this is where the control-area is heading so it will be well invested time.

What advice would you like to give to future participants? (I worked: > 41 timmar/vecka)

Nothing much. It's a tough course but it will be worth it!

Refresh on Python and optimization theory before-hand. Just use the lecture notes from the beginning and do all the practice questions.

Is there anything else you would like to add?

Is there anything else you would like to add? (I worked: 9-11 timmar/vecka)

Thank for that course ! The lecture were very good and clear and the challenge was nice !

The only little negative point is about the time of correction of the assignment. Please try to give a feedback two weeks maximum after the deadline because afterwards, we cannot remember well what we have done.

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

The live simulation session at the end of the project was real fun! Thank you Mikeal, Pedro, Hamed and Erik!

Is there anything else you would like to add? (I worked: 21-23 timmar/vecka)

No!

No, thanks.

Is there anything else you would like to add? (I worked: > 41 timmar/vecka)

In general, I found this course to be quite difficult given the lack of shown examples/figures and the flood of mathematical proofs. This created a lot of unnecessary confusion and I left the course not really feeling like I could actually apply this in any real-world scenario. The topic itself was good, but I feel like I just know enough to explain the concept, but not really implement.

## SPECIFIC QUESTIONS

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## RESPONSE DATA

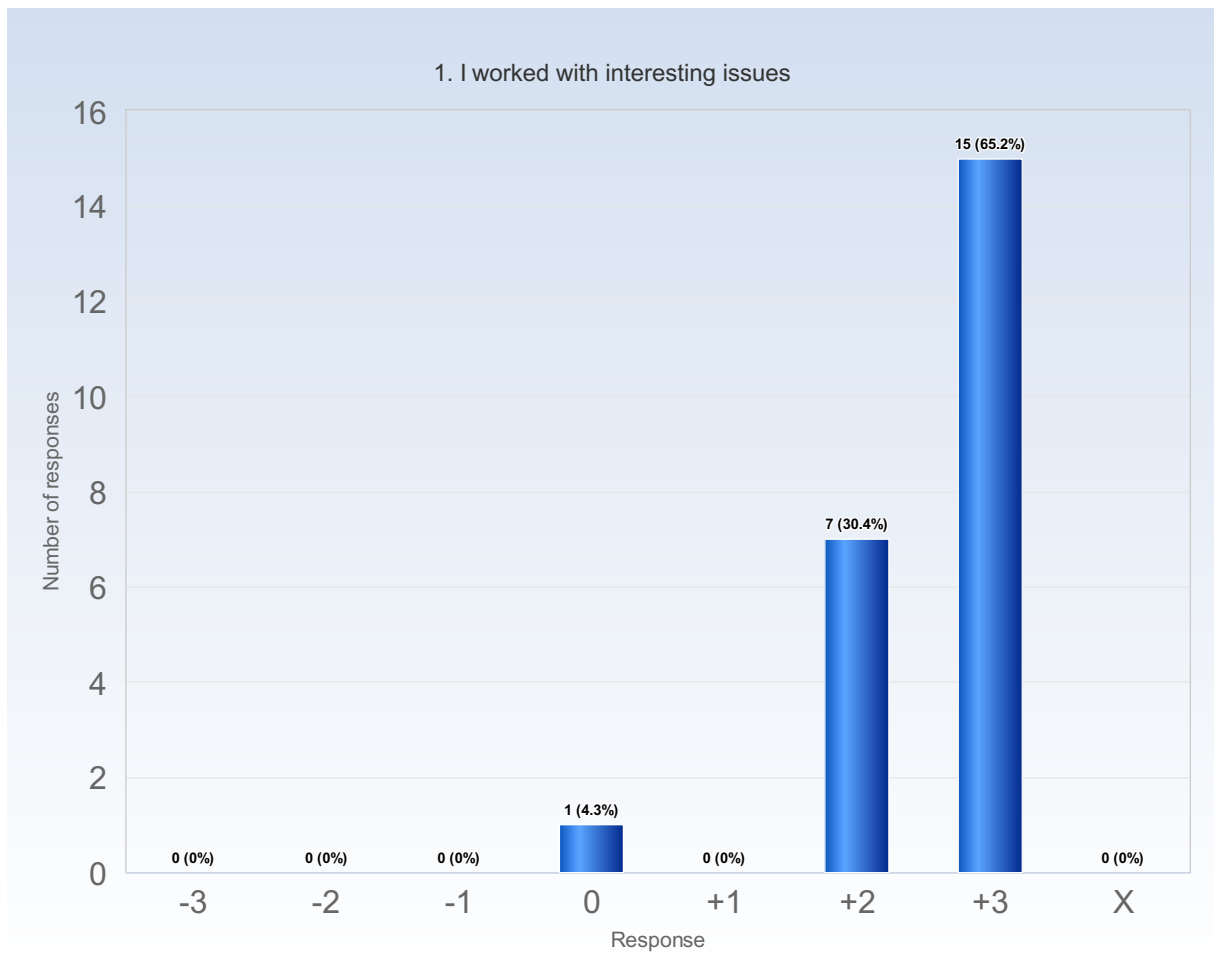
The diagrams below show the detailed response to the LEQ statements. The response scale is defined by:

-3 = No, I strongly disagree with the statement

0 = I am neutral to the statement

+3 = Yes, I strongly agree with the statement

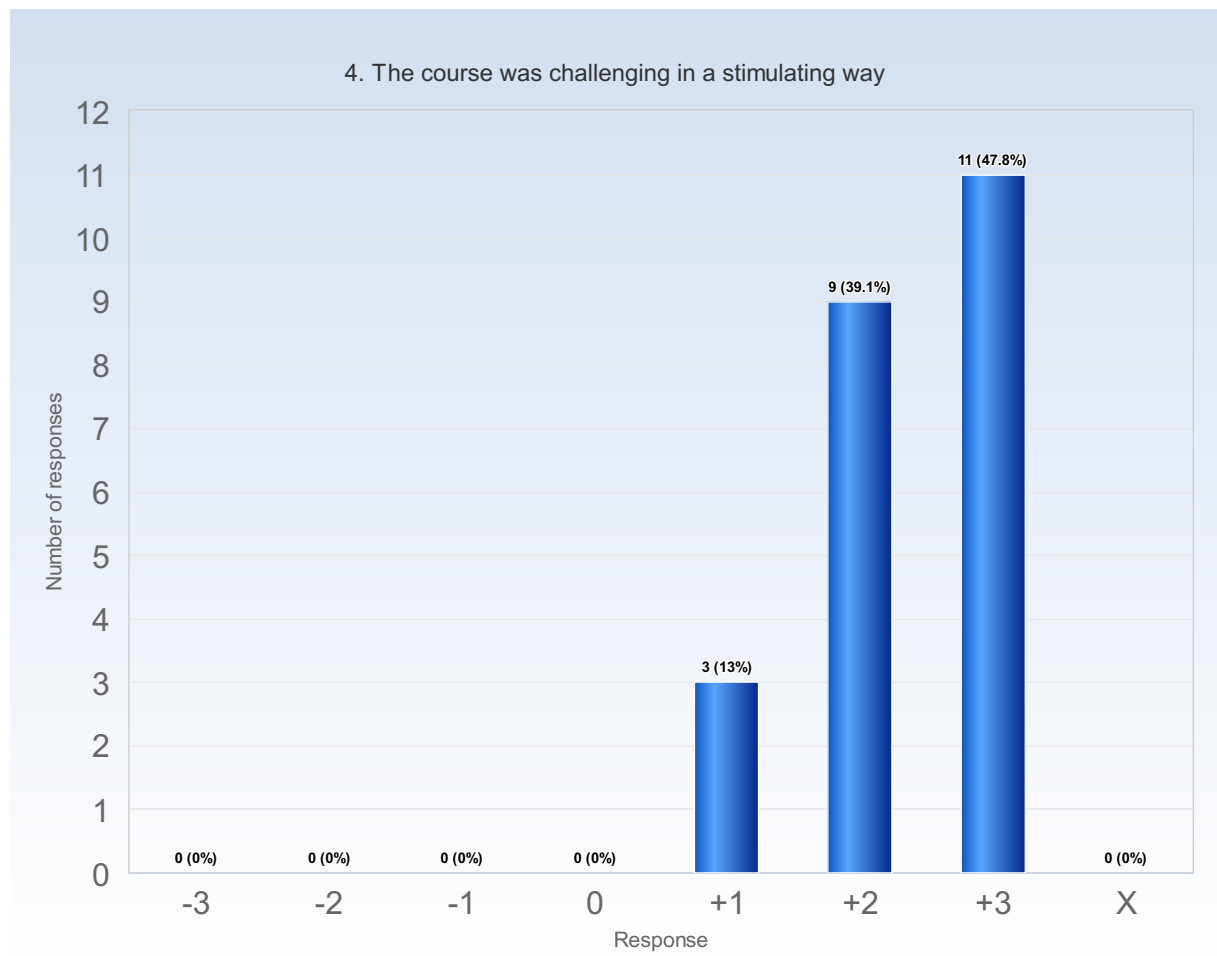
X = I decline to take a position on the statement



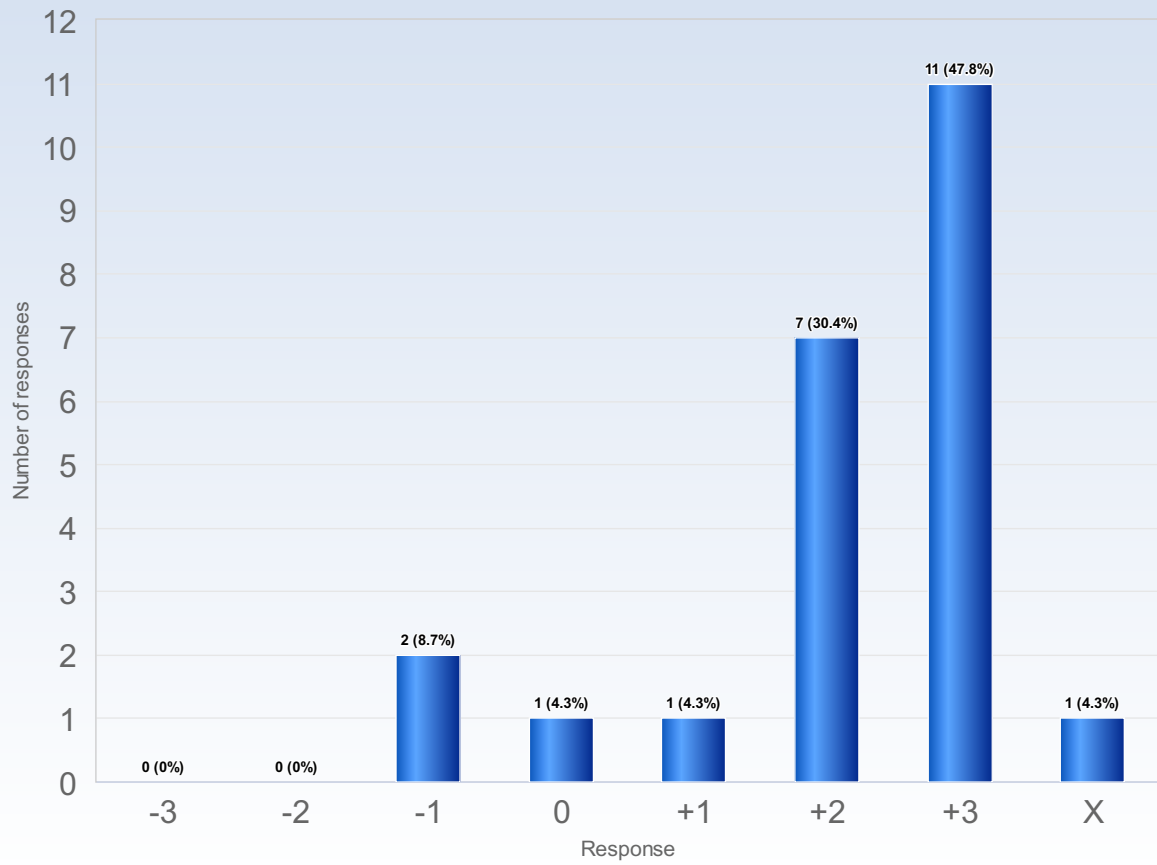
Comments

Comments (My response was: +3)

The labwork and project work was very interesting!



15. I was able to practice and receive feedback without being graded

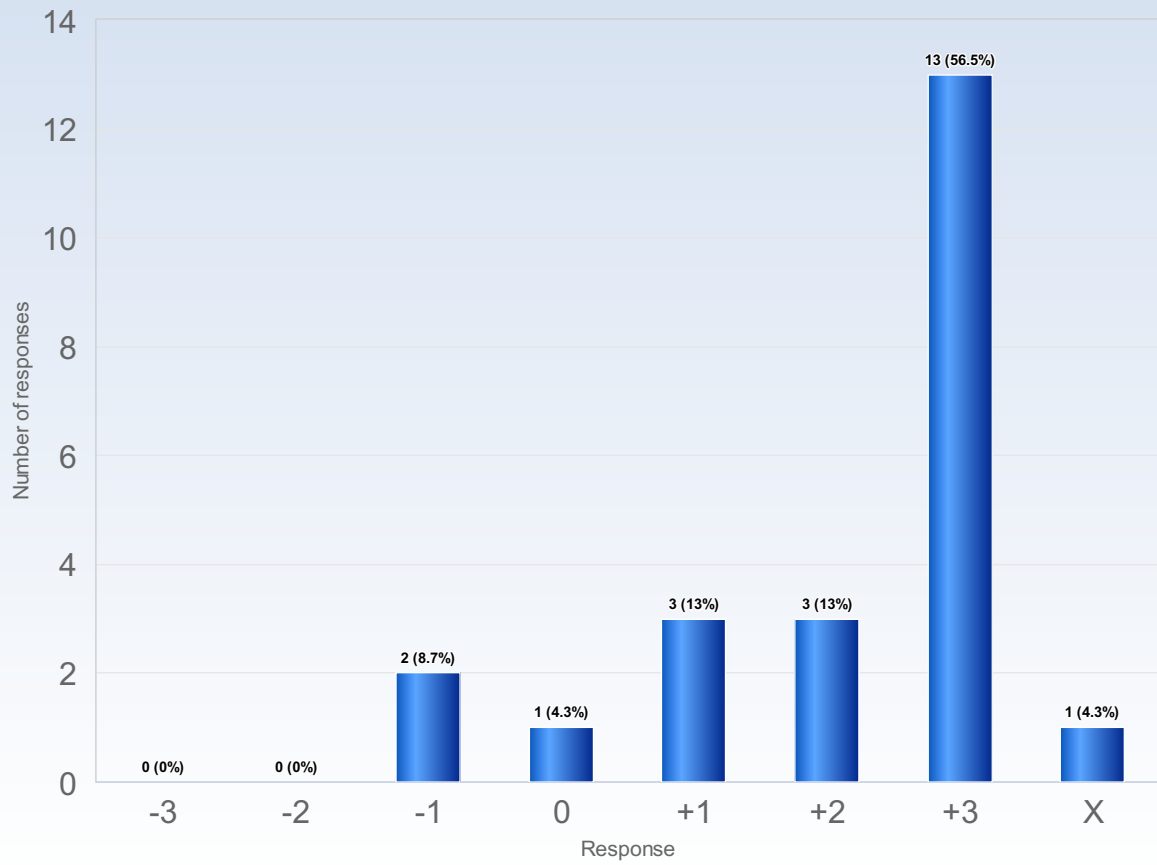


Comments

Comments (My response was: 0)

Yes in assignments but I give neutral due to that I find that they lack coupling to course core learnings.

16. The assessment on the course was fair and honest



Comments

Comments (My response was: -1)

Small details on the assignments meant we had to redo

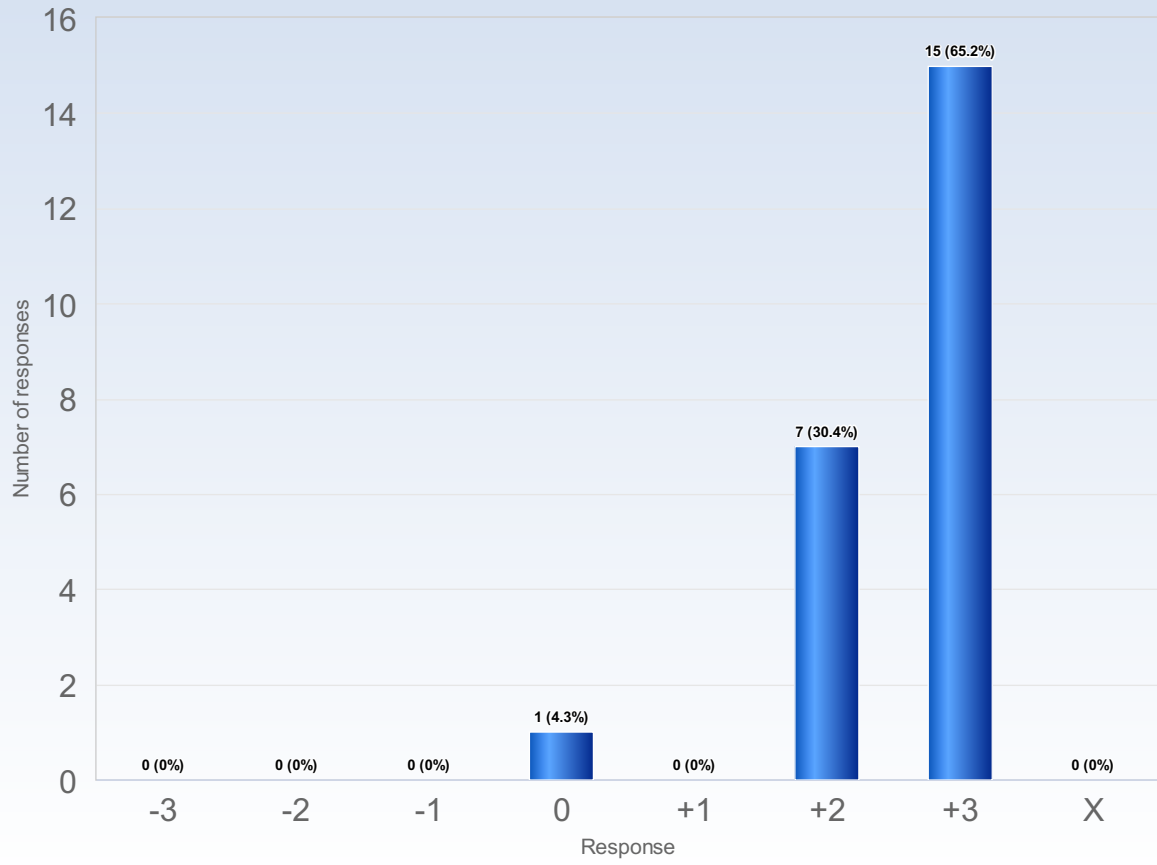
Comments (My response was: +1)

Exam assessment not yet uploaded

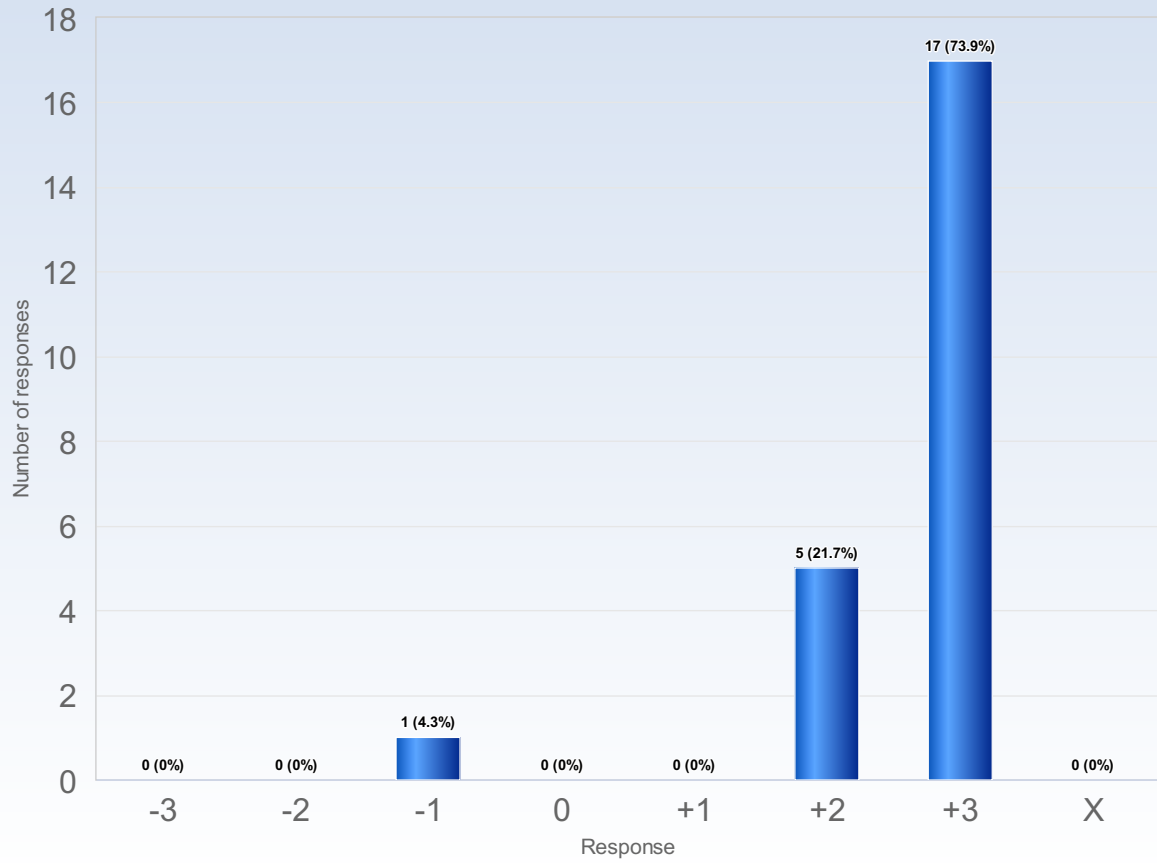
Comments (My response was: X )

The exam is not anonymous

21. I was able to learn by collaborating and discussing with others



22. I was able to get support if I needed it



Comments

Comments (My response was: -1)

Although there were TA help sessions, I sometimes think their explanations were not much more useful.