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Use of demonstrations and blended learning in the remote format in Physics

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The Physics UG programmes

- 250-280 students each year in one of the Physics programmes:
  - BSc Physics and Music Performance
  - BSc Physics with Theoretical Physics
  - MSci Physics
  - MSci Physics with a Year Abroad
  - MSci Physics with Theoretical Physics

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Programme Structure

Programme Structure[1]					
Year 1 – FHEQ Level 4 **You study all core and compulsory modules.**					
Code	Module Title	Core/Elective	Group*	Term	Credits**
	Practical Physics: Laboratory, Computing and Problem Solving	Compulsory		1-3	10
	Vector Fields, Electricity and Magnetism	Core		1-3	7.5
	Mechanics and Relativity	Core		1-3	15
	Oscillations and Waves	Core		1-3	15
	Statistics of Measurement and the Summer Project	Compulsory		2, 3	7.5
	Mathematical Analysis	Core		2, 3	5
				Credit Total	60

Curriculum review in 2019

Year 2 - FHEQ Level 5 **You study all core and compulsory modules. You choose one elective from group B and one from group C.**					
Code	Module Title	Core/Elective	Group	Term	Credits
	Advanced Practical Physics	Compulsory		1-3	10
	Thermal Physics and the Structure of Matter	Core		1-3	10
	Differential Equations and Electromagnetism	Core		1-3	10
	Quantum Physics	Core		1-3	15
	I-Explore	Elective	B	1-3	5/7.5
	Communicating Physics	Elective	C	1-3	5
	Suns, Stars and Planets	Elective	C	2, 3	5
	Mathematical Methods	Core		2, 3	5
	Environmental Physics	Elective	C	2, 3	5
				Credit Total	60/62.5

Curriculum review in 2020

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Year 3 - FHEQ Level 6
You study all core and compulsory modules. You choose elective modules to a total of 27.5-30 credits, from groups D, DT, E, F(Year 4) and FT(Year 4) with a maximum of one from group E, a maximum of one module from either F or FT and a minimum of 7.5 credits from either DT or FT (designated theory electives). We advise you to balance your work over Terms 1 and 2, but there is flexibility. With the agreement of the DUGS in both departments, up to 7.5 credits may be replaced with an elective module from another Imperial College department subject to space being available.

Code	Module Title	Core/Elective	Group	Term	Credits
	Nuclear and Particle Physics	Core		1	5
	Comprehensives	Core		1-3	15
	Solid State Physics	Core		1	5
	Advanced Classical Physics	Core		1	7.5
	Lasers	Elective	D	2	5
	Medical and Biological Imaging	Elective	D	2	7.5
	Principles of Instrumentation	Elective	D	2	5
	Statistical Mechanics	Elective	DT	1	7.5
	Complexity and Networks	Elective	DT	2	7.5
	Foundations of Quantum Mechanics	Elective	DT	2	7.5
	Computational Physics	Elective	DT	1, 2	7.5
	Plasma Physics	Elective	D	2	7.5
	Astrophysics	Elective	DT	1	7.5
	Group Theory	Elective	DT	1	7.5
	Year 3 Project	Elective	E	1, 2	7.5
	Essay Project	Elective	E	1, 2	7.5
				Credit Total	60/62.5

Year 4 - FHEQ Level 7
You study all core and compulsory modules. You choose elective modules to a total of 30-32.5 credits from groups F, FT, D (Year 3) and DT (Year 3) subject to a minimum of 60 credits at FHEQ level 7 by the end of Year 4 and a minimum of 37.5 from groups FT and DT (designated theory electives) by the end of Year 4. We advise you to balance your work over Terms 1 and 2, but there is flexibility. With the agreement of the DUGS in both departments, up to 7.5 credits may be replaced with an elective module from another Imperial College department subject to space being available.

Code	Module Title	Core/Elective	Group	Term	Credits
	Research Interfaces	Compulsory		1, 2	5
	MSci Project	Core		1-3	25
	Quantum Field Theory	Elective	FT	1	7.5
	Advanced Particle Physics	Elective	FT	2	7.5
	General Relativity	Elective	FT	1	7.5
	Cosmology	Elective	F	2	7.5
	Hydrodynamics	Elective	F	2	5
	Space Physics	Elective	F	2	7.5
	Quantum Information	Elective	FT	1	7.5
	Laser Technology	Elective	F	2	7.5
	Unification - The Standard Model	Elective	FT	1	7.5
	Quantum Theory of Matter	Elective	FT	2	7.5
	Quantum Optics	Elective	F	1	7.5
	Introduction to Plasmonics and Metamaterials	Elective	F	1	7.5
	Information Theory	Elective	F	1	5
	Entrepreneurship for Physicists	Elective	F	2	7.5
	Concepts in Device Physics	Elective	F	1	7.5
	Atmospheric Physics	Elective	F	2	7.5
	Optical Communications Physics	Elective	F	1	5
				Credit Total	60/62.5

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Physics Curriculum Review

- Fewer modules
- Acrive learning seminars for all core modules.
- Small group tutorials

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Pedagogical Transformation (Stream B) Project

- Improving the way we teach by introducing more opportunities for active learning during an undergraduate physics degree.
- Project started ~ 2 years ago.
- Two main themes of the project:
  - Enabling student learning and engagement prior to instruction in a blended learning environment
  - Physics demonstrations to create active learning

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Students' perspective on the flipped learning approach;

Effectiveness of pre-reading materials and quizzes in second year Atomic Physics

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Outline

- Course structure 2020
- COPUS review (Classroom Observation)
- Students' perspective:
  - End of the course surveys
  - SOLE surveys
  - Focus Groups
- Changes for the remote format in 2021
- Conclusion

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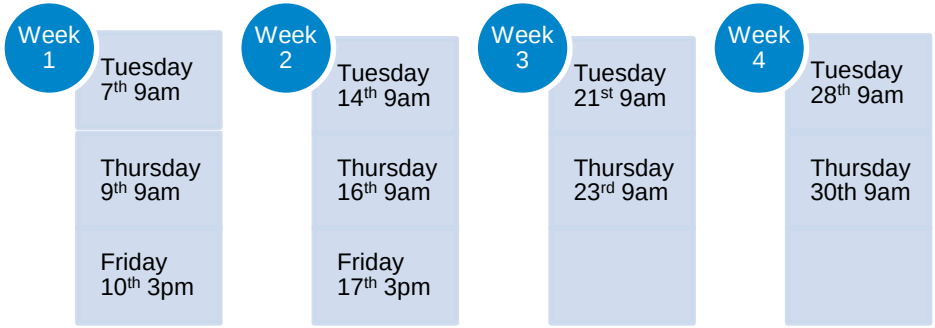
Course structure 2020

- 2nd Year course Atomic Physics course within the Atomic, Nuclear and Particle Physics module (Quantum Physics in 2021).
- The course consisted of 10 lectures, pre-lecture materials, 4 problem sheets and one assessed problem.



- 7 pre-reading quizzes introduced in 2020, 35 questions in total.
- Full marks (7.5% of the course) if score >30.
- Lecturer: Prof. Richard Thompson.

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Pre-reading quizzes

- Total number of students: 250

Quiz number	1-2	3	4	5-6	7	8	9
Ave score (5)	4.61	4.63	4.21	4.06	4.84	4.69	4.41
Attempts	251	249	246	241	243	232	241
Marked attempts	250	237	242	234	241	231	240

Extra questions like:

- Please give details of any topic in the notes that you are having difficulty understanding.

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COPUS Review

- COPUS (Classroom Observation Protocol for Undergraduate STEM) is a method used to characterize time use during teaching time for STEM courses [1].
- A modified version of this method was used to characterize time and resource use for the duration of the course.
- I have modified the original COPUS form and considered Instructor actions and Instructional tools.

[1] Smith, M.K, et al (2013) CBE Life Sciences Education, 12 (4), pp. 618-627.

Date: 10/01/2020 Class: Atomic Physics 19/20 Instructor: Richard Thompson No. students: Approx 150 Observer Name: Tom Nottingham

PR-Q	Pre-reading Quiz
PR-S	Pre-reading; Summarising
PR-R	Pre-readin; repeating pre reading materials
PR-A	Pre-reading; answering questions
PR-E	Pre-reading; Elaborating new materials
DA-PR	Directly Applying pre-reading in a new context
LMQ-PL	Lecturer Mentimeter Question; previous lectures
LMQ-PR	Lecturer Mentimeter Question; Prereading
LMQ_Rev	Lecturer Mentimeter Question; revision of the lecture
LMQ_JiTT	Lecturer Mentimeter Question; Just-in-time teaching
LMQ-BK	Lecturer Mentimeter Question; Background knowledge

Lec	Lecturing
RtW	Real-time writing on board, doc. projector, etc.
SMQ	Student mentimeter question (lecturer answering questions submitted via Mentimeter)
SDQ	Student direct question (a student asked a question verbally during the lecture)
LDQ	Lecturer direct question (lecturer asked a question verbally during the lecture)
D/V	Showing or conducting a demo, experiment, simulation, video, or animation
Adm	Administration (assign homework, return tests, etc.)
W	Waiting-For students responce,...explain in comments
O	Other – explain in comments

PPT_txt	text in PPT
PPt_fig	figure, plot and images in PPT
PPt_vid	video embeded in PPT
PPt_gif	annimations and gifs in PPT
BB	Blackboard
WB	Whiteboard
Vis	Visualiser
Demo	Demonstration
Mov	Movies (from pc or online)
CRP	Classroom Response System like Mentimeter
SSV	software, simulation, visualisation or websites
NON	No instructional tool or technology

Time	Instructor actions																			Instructional Tools												Comments
			Pre-reading						LMQ-											PPT-				Writing									
t (min)	Lec	RtW	PR-Q	PR-S	PR-R	PR-A	PR-E	DA-PR	BK	PL	PR	Rev	JiTT	SMQ	SDQ	LDQ	D/V	Adm	W	O	txt	fig	vid	gif	BB	WB	Vis	Demo	Mov	CRS	SSV	NON	EG: explain difficult coding choices, flag key points for feedback for the instructor, identify good analogies, etc.
0-2					2																			2								
2-4					2																			2								
4-6					2																			2								
6-8					2																			2								
8-10					2																			2								Recap of the spherical harmonics from the prereading
10-12					1.5										0.5									1.5							0.5	
12-14					2																			2								
14-16					2																			2								Projector broken, would have been using it if it was working - instead the lecturer demonstrates the concept of effective radial potential on
16-18					2																			2								
18-20					2																			2								
20-22					2																			2								Further recap of spherical harmonics
22-24					2																			2								
24-26							2																	2								
26-28							2																	2								Going further with spherical harmonics
28-30							2																	2								
30-32		2																						2								
32-34		2																						2								
34-36		2																						2								
36-38		2																						2								Introducing spin-orbit interaction: This was done really well, clearly showing where the s·l term comes from
38-40		2																						2								
40-42		2																						2								
42-44		2																						2								
44-46		1																						1								
46-48																																
48-50																																
50-52																																
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54-56																																
	0	15	0	0	23.5	0	6	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	44.5	0	0	0	0	0	0	0.5	
	15	29.5	0	0.5	0	44.5	0.5																									

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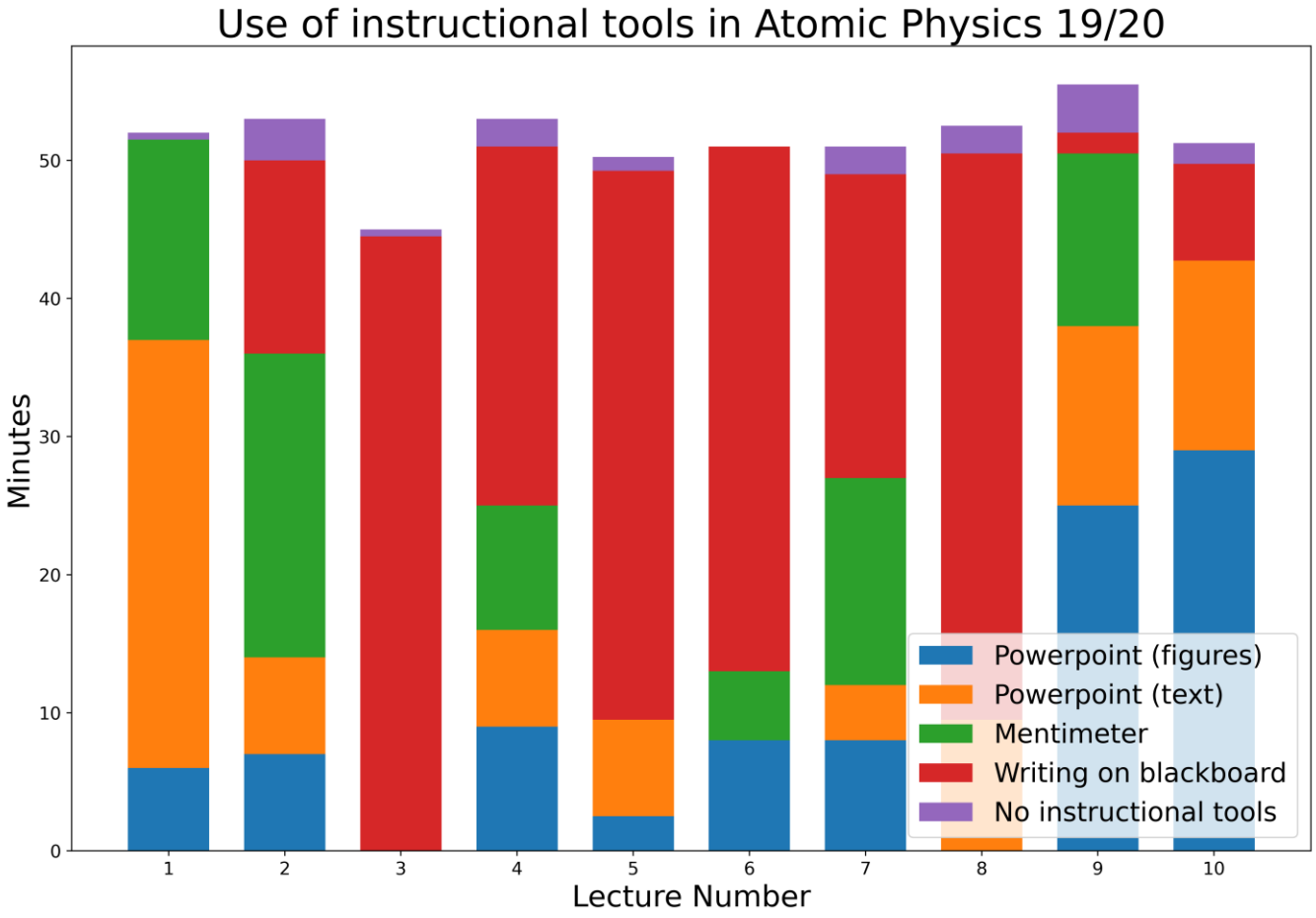
The Classroom Observation Protocol for Undergraduate STEM (COPUS)



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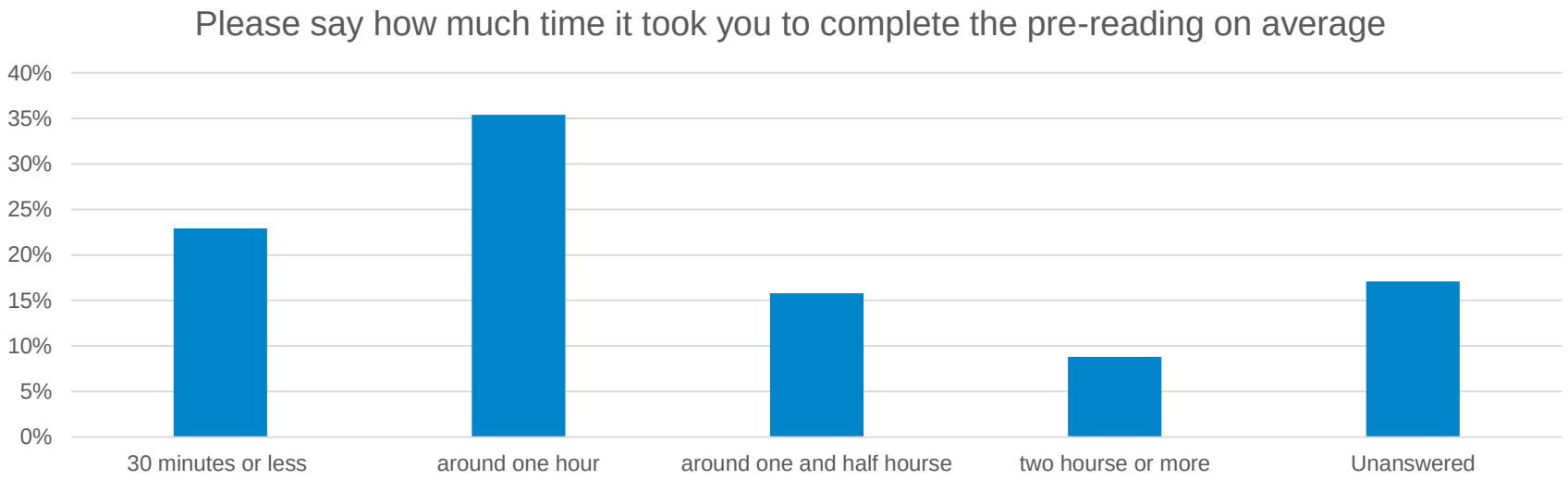
During the course surveys

- At the end of quiz 7



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During the course surveys

- **What would encourage you to attend more of the lectures?**
  - No more 9AMs (repeated by 17 students)

    The lecture timings are really awkward. We have a AP lecture at 9 etc, then our next one is at 12.

    Nothing - they're generally good lectures. it's just a lot easier to learn when you have a pause button and wikipedia at hand for anything you don't understand

  - Nothing, already attending, they're already very good (x ~ 15 students)

    Nothing - they're generally good lectures. it's just a lot easier to learn when you have a pause button and wikipedia at hand for anything you don't understand

  - Doing exam-like questions in lectures. (x~ 15 students)

    Going through examples. I feel like I have learned a lot of facts, but am incapable of doing anything with them. I learn best by example and struggle to do problems on my own for the first time.

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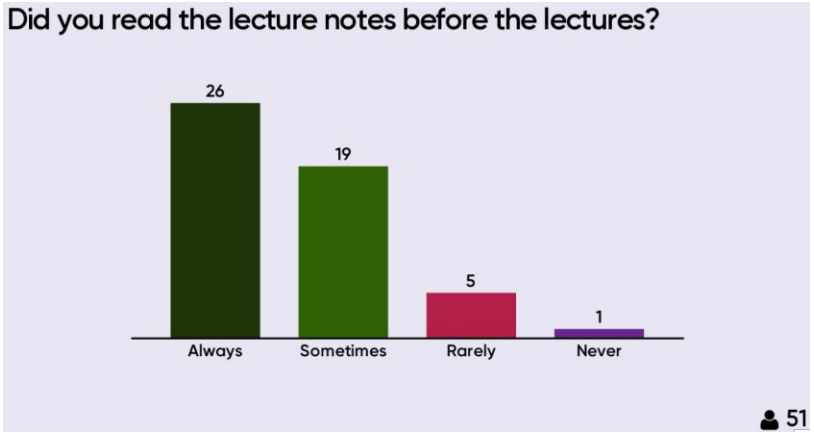
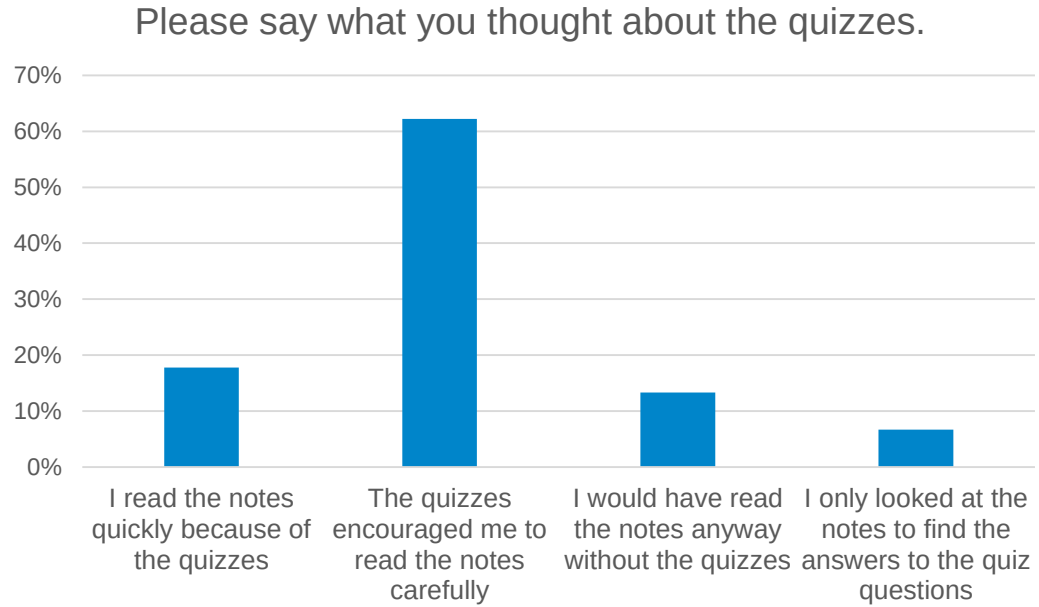
End of the course surveys

2019 (without quizz)



2020 (with quizzes)



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End of the course surveys

Please say ONE thing that you liked about the course? (37 responses)

- Pre-reading quizzes (x14 students)
- Pre-reading notes (x8 students)
- Clear Structure (x6 students)
- Mentimeter (x4 students)
- Lecturer (x3 students)

Liked trying to explain a topic in a different way

largely incorporated active learning, so I was more engaged

The only course I feel on top of. The pre-lecture quizzes really helped.

we were encouraged to read notes before lectures which made understanding material in lectures easier

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End of the course surveys

Please say ONE thing about the course that could be better (29 responses)

- Go through worked examples (x8 students)
- More chalk on board in lectures (x3 students)
- Nothing (x3 students)

Understanding of what we needed to know for the exam

Making sure the lights are on, hard to read board on panopto

Assessing before lecture is wrong on principle

Too many pre-lecture quizzes: it was easy to forget doing one f them. Maybe reducing the total number of quizzes would be better, like doing one quiz weekly.

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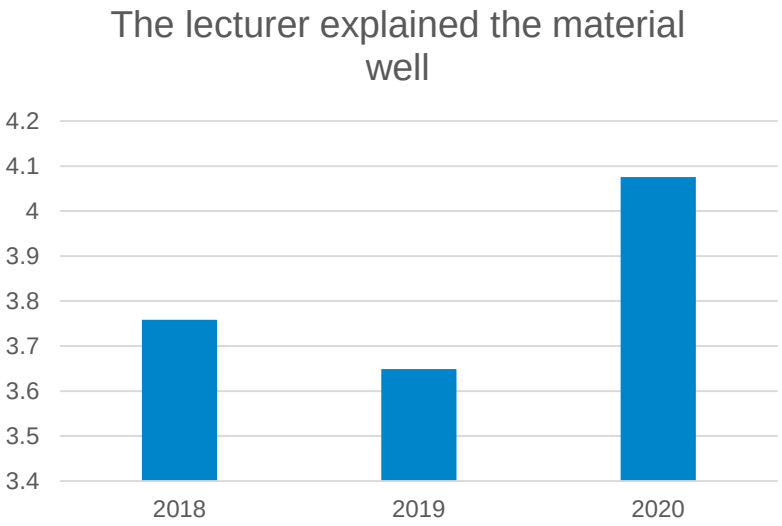
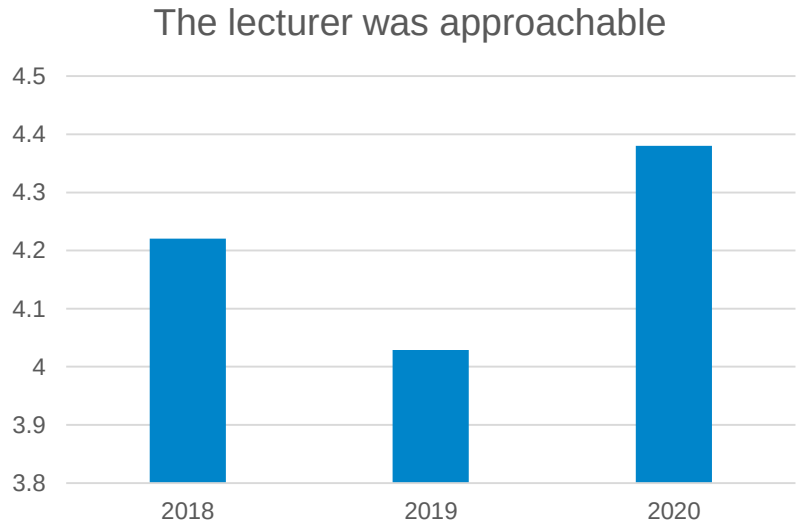
SOLE surveys





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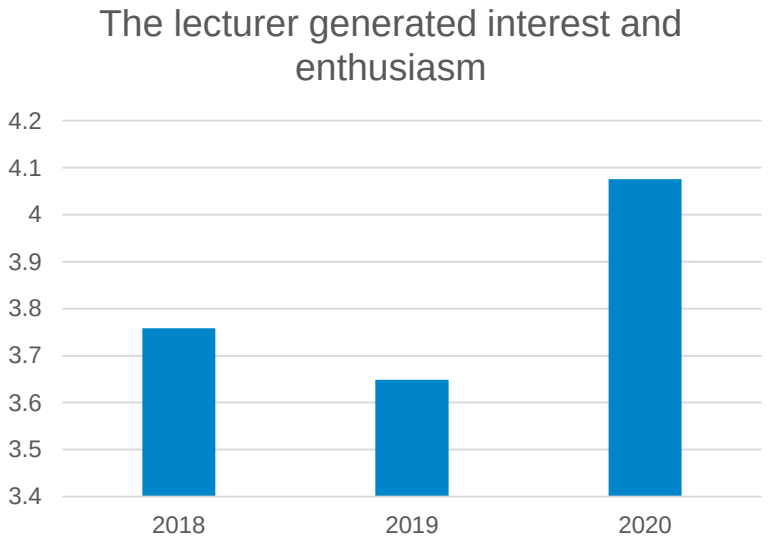
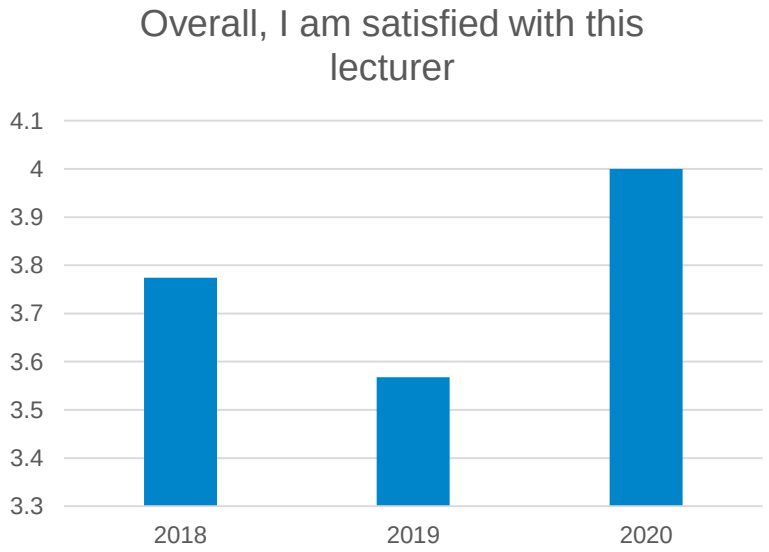
SOLE surveys





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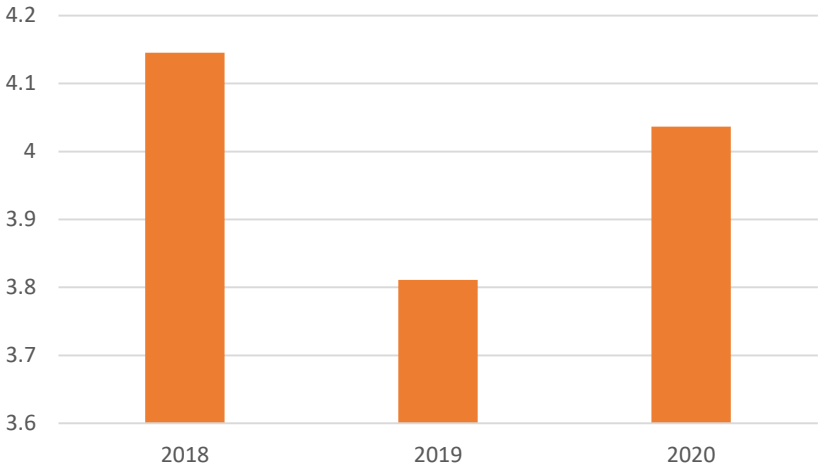
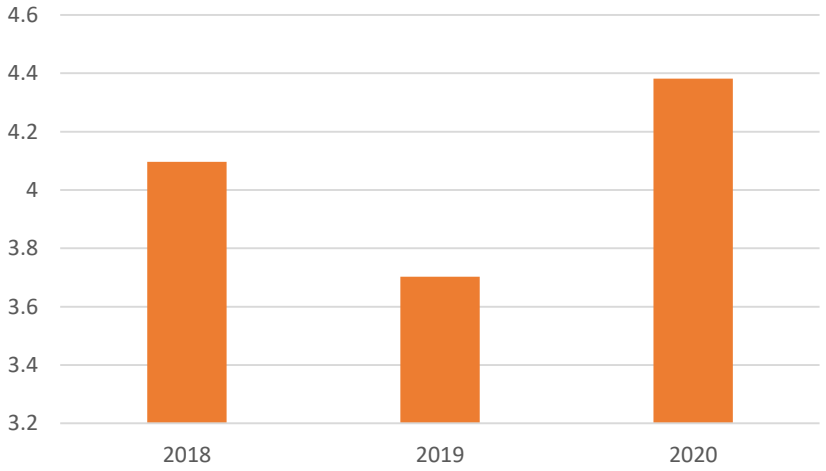
SOLE surveys

The content of the module is well structured



The content of the module is intellectually stimulating



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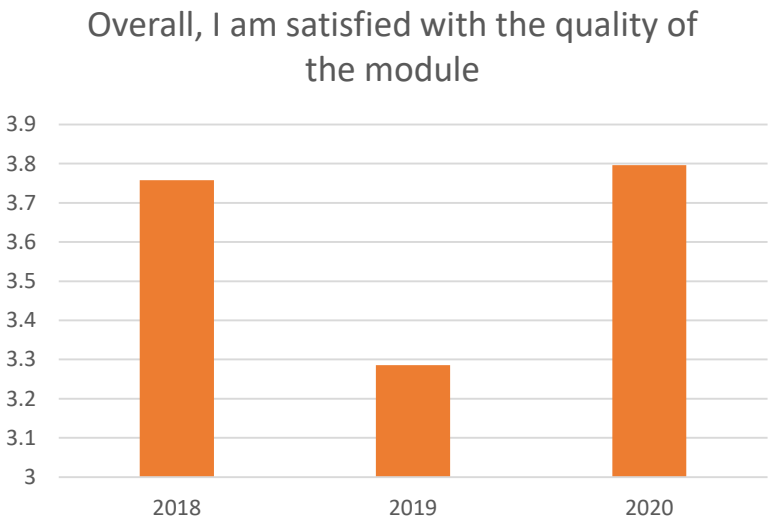
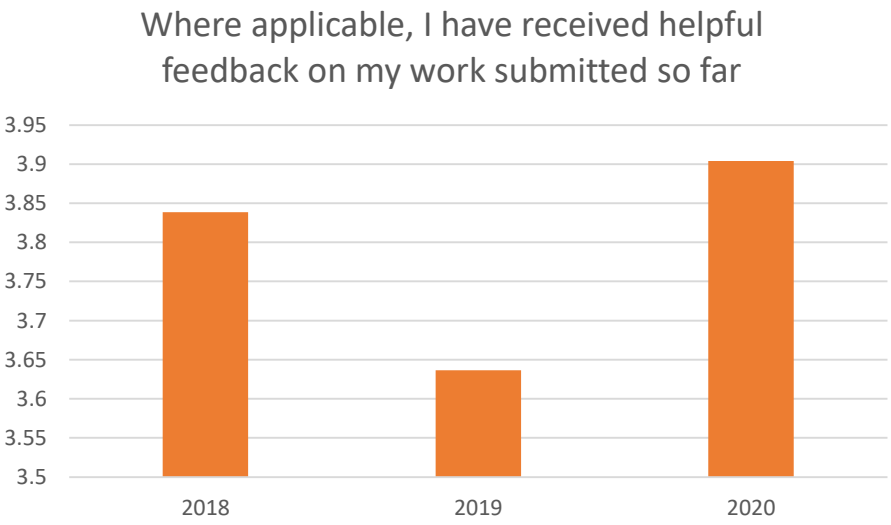
SOLE surveys





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SOLE surveys

- The results show generally that the students liked the lecturer more in 2020 than they did in 2018, and a lot more than they did in 2019.
- The students found the content and delivery of the module similar to or better in 2020 than in 2018, but far better than in 2019.
- In general, all three years received positive feedback.

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Focus Groups; Mentimeter

- In general, feedback on Mentimeter questions was very good.
- Most people thought that there were a good number of questions and that they helped to check their understanding.
- Most of the participants were unaware of the existence of the Mentimeter app.

C1: Personally, I always find Mentimeter in lectures good as a bit of a break. It's a way of getting back to focussing. I always do them, and I find them useful in focussing my attention.

D3: I think one thing was, I think mentimeter questions should be **made available after lectures** as well, because I think I slept through quite a few lectures and then later on when I watched, the Panopto recordings, I would have preferred having those side by side, probably as some sort of a file separately that's uploaded after the lecture.

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Focus Groups; Pre-reading

- Most students liked the pre-reading and pre-reading quizzes
- Although there was a sentiment that pre-reading quizzes should be optional, or at least not for credit.
- Some shared a feeling that assessing content before it had been taught in the lectures was against the spirit of an undergraduate course, even for the small amount that it was worth.
- These people, however, did generally recognize the need for an incentive to perform pre-reading.

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Focus Groups; Pre-reading

C2:
I think that I understood much more at the end of the lecture course because of the prereading.

B1: Ok this I am completely for, because it's something I've always done since coming to uni. I thought this was really good that prereading was encouraged. I found that this was one of the courses where I remembered the most from the lectures themselves. Reading the lecture notes helps you take away the parts that you find tricky and then you can pay attention to them in the lectures. If I know where I need to focus it makes it easier to remember stuff when it came to exam season.

C3: ….**I tend to get very lost in lectures** sometimes, you look away for one minute and you don't know what is going on anymore. **Pre-reading means you are less likely to get lost** and you can catch up more quickly.

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Focus Groups; Pre-reading quizzes

D2:

- I'd say it was a **really good way of motivating** students to read the notes before the lecture.
- For me, if there hadn't been any pre lecture **quizzes I wouldn't have read the lecture notes** ahead most of the time. So that was a good way of just getting you motivated to actually do this stuff.
- I think the **difficulty level was good**. I wouldn't want them to be any more difficult really.
- You could answer the questions well based on reading the lecture notes thoroughly.
- If you just **like flip through the pages you can't answer all** of them, but equally, you don't have to spend hours studying the subject to answer the questions, which I think is good because at the end of the day the pre-reading is just to familiarise yourself with the material, it's not like you're meant to study everything ahead of the lecture, so they shouldn't be too difficult in my opinion.

D4:

- Pre-reading **quizzes are essential** for me, I am always worried about misunderstanding the concepts and they help me figure out if I understood them.
- The quizzes are very easy compared to the problem sheets, but I think it's enough as a check for prereading. **If they gave me hard problems and I did them right, I think I wouldn't go to the lectures**.

D1: …..I think probably the **more difficult the better for the pre-reading quizzes**…..

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Focus Groups; Pre-reading

Do you think this way of teaching could be extended to other modules?

- In terms of the possibility of extending this pre-reading style to other courses, most students thought that it was not feasible to do it for all courses.
- Most thought that with even only one course employing this style of teaching, they struggled for time during the week.

C3: Yeah, I would agree with that.

C1: Please no. The amount of extra time it takes – if that was for all courses I would die under the workload. Just have all options available to students and let them choose themselves.

C2: I think now, in this new 'era', we have to appreciate that **different people have different learning styles**, and learning styles are so varied. Some people just don't enjoy lectures and need Panopto. I don't think we should force people to subscribe to a particular way of learning. So I think – **give people the option,** show them the benefits and statistics to show that it helps to pre-read, but at the end of the day, let them make their own decision.

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Changes in 2021

- The course consisted of 9 lectures
- 9 pre-lecture material and 8 quizzes, 40 questions in total.
- No mark for quizzes this year. However, they could only see lectures on Blackboard, when they obtained 80% (4/5 question correct).
- They could repeat the quizzes till they get the required mark.
- We still used Mentimeter questions on Panapto/ Blackboard. We used recorded videos of previous year for the mentimeter discussions.

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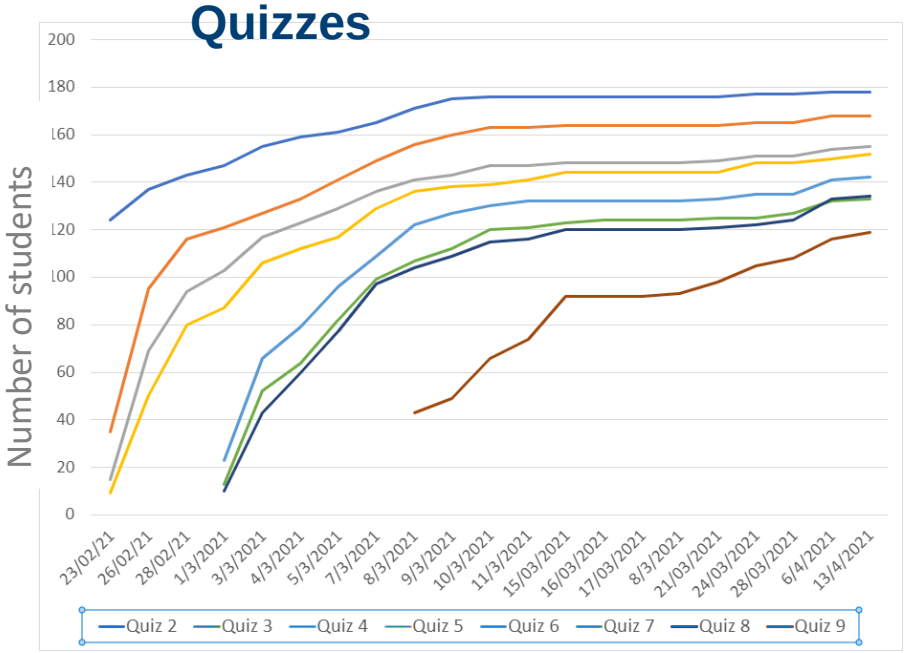
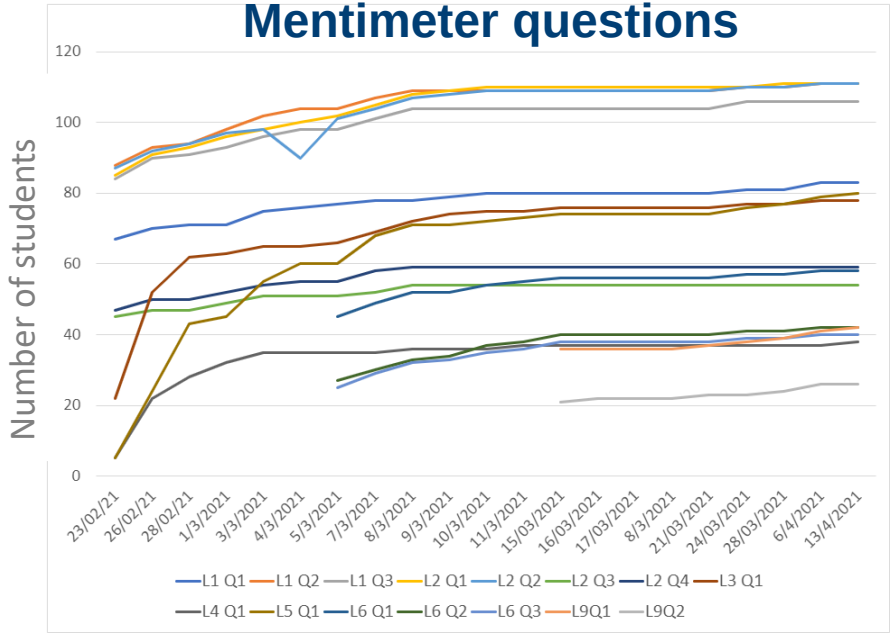
When did students watch the lectures?





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Flipped learning summary

- Overall, students are very happy with the Atomic Physics course.
- Most students thought that there were a good number of **Mentimeter** questions and that they helped to check their understanding.
- Most students liked **pre-reading** materials and found them very useful to enhance their learning.
- Students found the **pre-reading quizzes** very helpful. A few of them though they can be more difficult.
- Most students want more exam-style and **worked examples**, on board.

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Use of demonstrations in lectures

- Pros and Cons of demonstrations
- Interactive demonstrations
- Students’ survey
- Demonstrations in remote teaching

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Why you may think using demos is a bad idea….

- Poorly planned demos can confuse the students
- Demos take up quite a lot of time!
- Demos can go wrong (technical issues, visibility, …)
- Some research shows demonstrations may not help student understanding[1]

1. K. Miller, *et al*, “Role of physics lecture demonstrations in conceptual learning”, Phys. Rev. ST Phys. Educ. Res. 9, 020113 (2013).

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Why most of lecturers think it is a good idea

- Entertainment, break up lectures, keep attention high, help memory
- Seeing a phenomenon which has just been discussed theoretically in a lecture brings it vividly to life
- They emphasize that physics is about the real world not just equations.
- Actually help deeper understanding, but only if there is an active element!

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Interactive demonstrations

Research indicates that *interactive demonstrations* can improve student understanding[2,3]. For instance:

- The students can be asked to predict the outcome of an experiment
- The experiment is carried out in the lecture.
- The students reflect on the outcome.

2. D.R. Sokoloff and R. K. Thornton, “Using interactive lecture demonstrations to create an active learning environment”, The Physics Teacher 35, 340 (1997).
3. M.D. Sharma, *et al*, “Use of interactive lecture demonstrations: A ten year study”, Phys. Rev. ST Phys. Educ. Res. 6, 020119 (2010).

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Interactive demonstrations

Research indicat… student understanding[2,3].

- The students…
- The experim…periment
- The students…

Demos can be an effective active learning experience, both authentic and inclusive, but requires lot of preparation, delivery can be challenging!

2. D.R. Sokoloff and R. …eate an active learning environment", The Phys…
3. M.D. Sharma, *et al*, "… Phys. Rev. ST Phys. Educ. Res. 6, 020119 (2010).

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Interactive demonstrations in Physics

2019

- 9 demos for Mechanics, year 1
- 2 demos for Fourier, year 1&2
- 1 demo for Elect&Magn, year 1
- 2 demos for Osc&Waves, year 1
- 2 demos for Diff. Eq., year 2
- 2 demos for Light&Matter, year 3
- 1 demo for Laser Tech, year 4
- 2 for Plasm&Meta, year 4

2020

- Filmed all the above
- 3 DIYs for Mechanics
- 6 DIYs for Thermo&Matter, year 2
- 1 more for Laser Tech
- 1 more for Plasm&Meta
- 2 demos + 3 DIY for Hydrodynamics, year 4

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Interactive demonstrations come in many forms

- DIY demos for students to replicate at home
- Simple and quick to illustrate a concept or provide a break
- Lecture/tutorial built around a demo
- Lecture built around an experiment in a real research lab
- Help-desk, tutorials

- Active element: Mentimeter questions, group work, make predictions, reflect on outcome

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Students' survey (2019-2020)

13 Questions + free feedback

1. Demonstrations encourage students to participate in lectures
2. Demonstrations create opportunities for asking questions about the physics phenomenon
3. Demonstrations were delivered efficiently in the lectures
4. Demonstrations helped improve understanding of the physics being taught
5. Demonstrations were entertaining, they helped make the lecture more interesting
6. I could see the demonstration clearly
7. The questions associated with the demonstration were helpful
8. Demonstrations were explained clearly
9. Demonstrations related the theory to a visible, real world example
10. Demonstrations maintain student interest during lectures
11. Demonstrations help provide varied and lively lectures
12. Demonstrations were structured well in the lecture organization
13. Demonstrations help to increase enthusiasm for the physics

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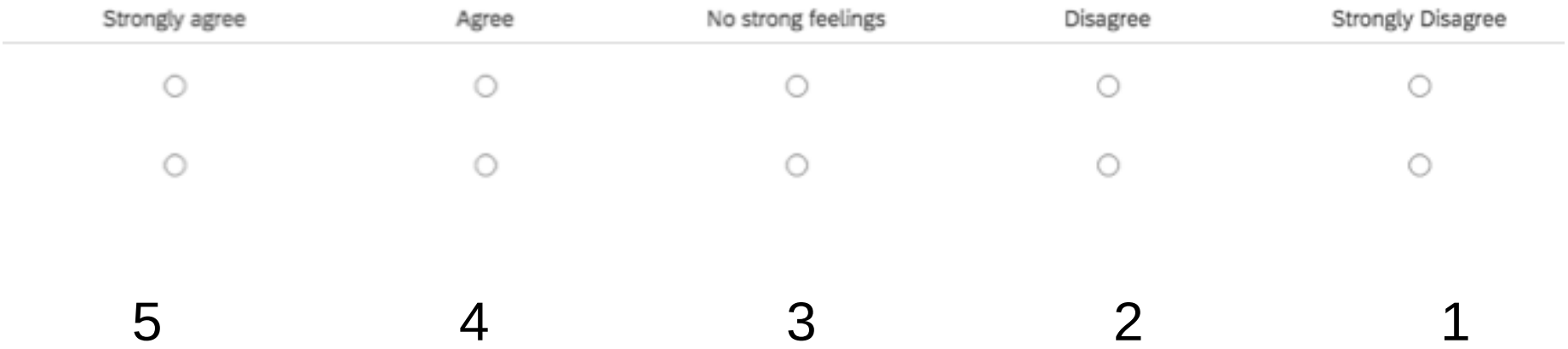
Multiple choice questions



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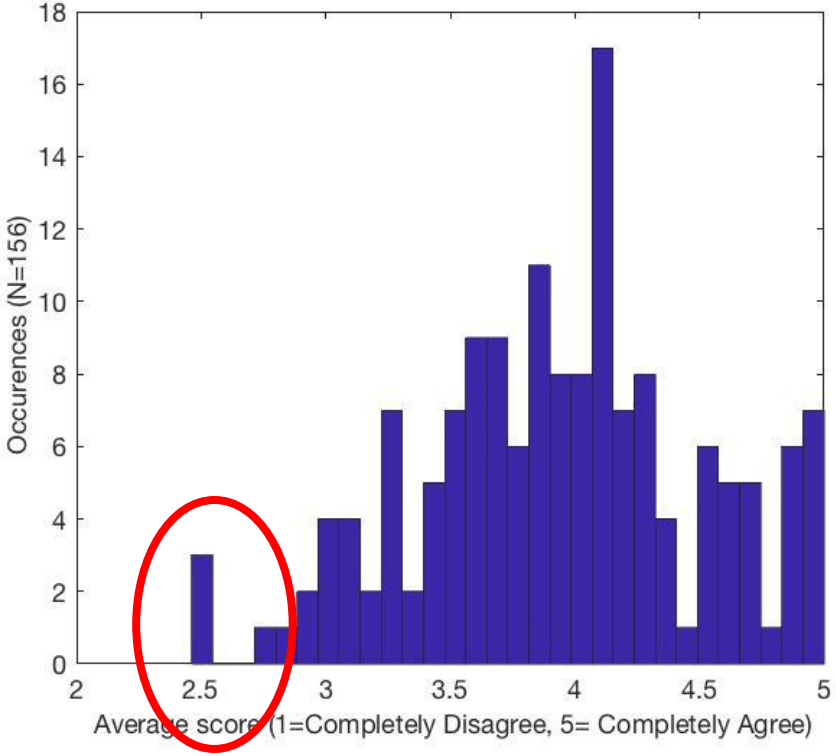
General feedback

- 156 UG students
- Overall positive feedback, average score = 3.94
- Distribution of each student's average score over 13 questions
  - Only 3 students significantly below average
  - Most students around 4 with a good number in 4-5 range!



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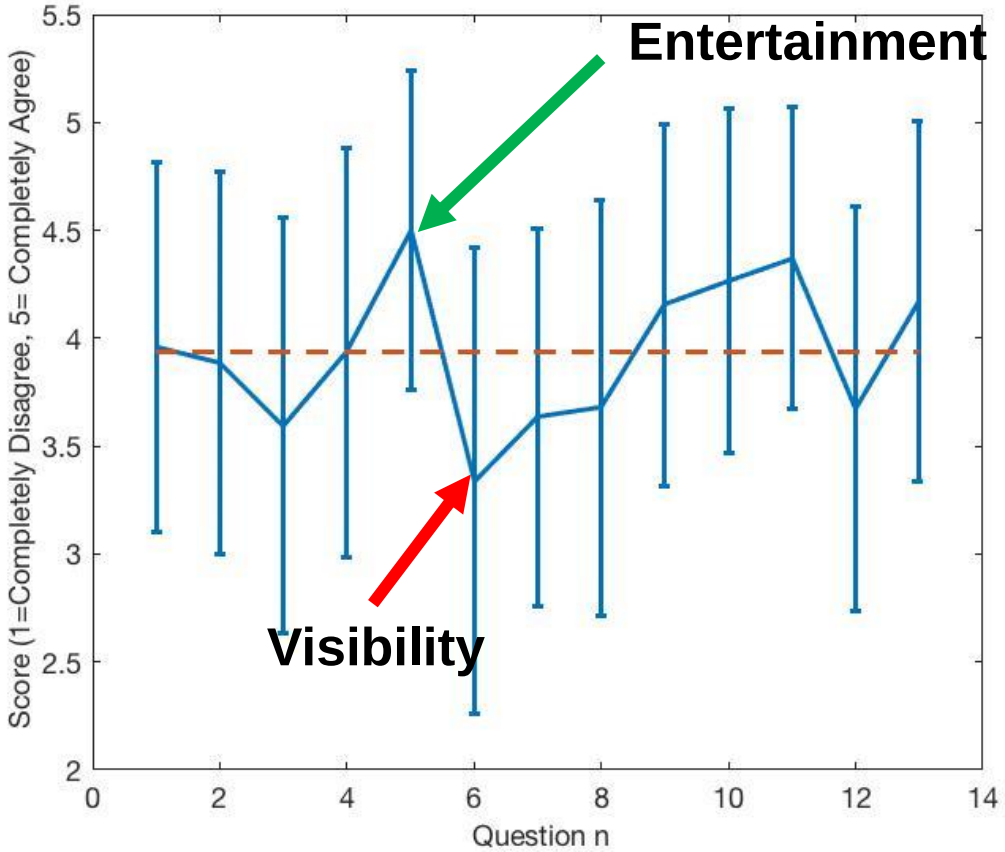
A look at each question

- All questions scored positively
- Some questions received a more positive feedback



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Students correctly perceive and appreciate the aims of demonstrations

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Students correctly perceive and appreciate the aims of demonstrations

However their delivery can be challenging

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Demonstrations for remote teaching

- All demos were already recorded for inventory and sharing purpose!
  - Aim is to create a repository, make them more accessible to lecturers
- Developed more DIY demos for students to play at home
- Mitigated some of the drawbacks from past year
  - More preparation, effective delivery, no issue of visibility
- Obviously we lost direct interaction with students
- Running same survey this summer + couple of questions on remote

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Thank you for listening!

Any questions?