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# How can we increase the (perceived) benefit of exercise classes to the students?

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## Description of the problem and the aim

In the physics curriculum at the University of Copenhagen, a considerable amount of time of the teachers and teaching assistants (TAs) is spent on exercise classes. Likewise, the students are expected to spend considerable time on them. Naturally, this time should be spent efficiently, to the best possible benefit of the students, to achieve the highest possible learning outcome. At the same time, the students also have to perceive the exercise classes as beneficial, since otherwise they do not show up and thus do not benefit (or are not motivated to actively participate, and thus benefit less). The possible difference between perceived and actual benefit is of course partially a question of constructive alignment (Biggs, 1996; John & Catherine, 2003) and congruence (McCune & Hounsell, 2005).

In many courses of the theoretical physics curriculum, the exercise classes consist of supervised exercise solving (where the students solve the exercises alone or in groups, being able to ask questions to the TA once they occur) and/or presentations of the solutions by the students or the TA. In the courses with student presentations of the solutions, teachers and TAs report of considerable reluctance of the students to present.[1] It seems self-evident that supervised exercise solving (alone) is not a very efficient use of the students', teachers' and TAs' time, in particular since some students

[1] When I was TA a couple of years ago in the third-year Bachelor course "Mathematical Methods in Physics 3", I polled the students on this; a clear majority of students preferred supervised exercise solving over student presentations.

do not look at the exercise sheet before the beginning of the classes. At the same time, student presentations provide more active learning opportunities for the students than presentations by the TA. Moreover, supervised exercise solving and presentation of the solutions by the TA allow only for limited amount of feedback to the students, in particular of formative feedback; see e.g. Hattie, 2018 for a meta analysis showing the positive impact of feedback on learning.

In many courses in the theoretical physics curriculum with oral exam, the oral exam starts with a student presentation on a topic covered in the lecture, followed by questions on the presentation as well as more general questions on the course. Thus, the exam provides little incentive for the students to do the exercises, unless the exercises are about some details on these topics that were left out in the lectures. In particular strategic learners, but also also more intrinsically motivated students that are subject to a high work load from other course, thus do not do the exercises and do not participate in the exercise classes. This is an example of the so-called 'backwash effect' of assessment (John & Catherine, 2003; Watkins et al., 2005).[2]

The combination of the effects described above has lead to low perceived benefit and thus low attendance rates in the exercise classes of many courses, as confirmed also in student interviews I did with three students of the course "Introduction to the Gauge-Gravity Duality" part of which I taught in 2019.

The aim of this project is to design, implement and evaluate a catalog of course elements to increase the benefit as well as the perceived benefit of the exercise classes to the students. As such, this project builds on my pre-project titled "On the Perception of After-Lecture Activities" in collaboration with others, as well as on my congruence assignment.

## Background information on the course

The course "Quantum Field Theory 1" is part of the study track "High Energy Theory and Cosmology" in the specialization "Quantum Physics" within the Master of Science in Physics, but it can also be participated in as

[2] In general, the 'backwash effect' of assessment describes the effect assignments have on student learning when the learning outcomes that are sought after are perceived to differ from those rewarded by the assessment (exam).

part of other study tracks. When I taught this course in block 3 (February-April) 2020, 37 students were enrolled in it. According to a survey on the students' background, interests and plans I conducted one month before the start of the course, 34 of those were Master students, 2 PhD students, and 1 a Bachelor exchange student. In addition, 1 Bachelor student attended the lectures without being enrolled.

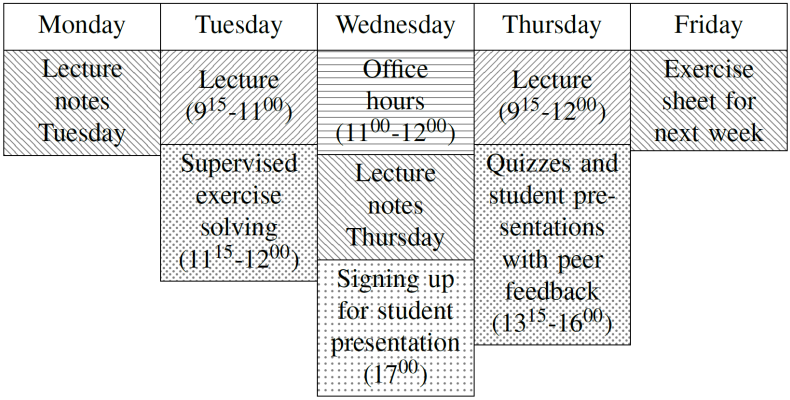



**Figure 1.** Different course elements as distributed throughout the week. Lectures are shown on north east lines, exercise classes on crosshatch dots, office hours on horizontal lines, announcements on Absalon of the specified documents on north west lines, and communication by the students via Absalon on dots.

The course was previously taught by another teacher, before I took on the role of course responsible this year, this being the first time I was course responsible for any course. I taught the course together with one TA, who was also TA for this course the previous year.

According to the course description that I inherited from the previous year, the intended learning outcome (skills) of the course is as follows: "The goal of the course is to introduce the student to quantum field theory, such that she/he is able in an oral exam to explain in a clear and transparent way the foundations of quantum field theory as well as how to use the theory to perform calculations."

On the Wednesday the sixth of seven weeks of teaching, the lockdown of the University with immediate effect was announced due to the Covid-19 pandemic, necessitating a shift to online teaching on a short notice.[3]

## Description of the different course elements and rationale behind them

In the following, I describe the different course elements that I included in the course with the aim to increase the (perceived) benefit of the exercise classes.[4] A schematic time table for the course is given in figure 1.

Most of the students took the course in the second half of the first year of their Master studies. They were thus used to a certain learning culture as well as format of course and exercise classes described in the first section of this report, which is sometimes described as implicit didactic contract (Brousseau, 1997). In order to renegotiate this didactic contract, I took care to communicate the different course elements as well as my reasoning behind them to the students: via the Absalon page, in the first lecture, as well as further on as reaction to student feedback.

**Exercise-based exam.**[5] Instead of starting the oral exam with a 10-15 minute presentation on a topic from the lecture (as done in previous years), I decided to start the oral exam with a 10-15 minute presentation on the solution to one of the exercise sheets (drawn randomly among the seven), which should focus on one important step of the calculation (of the student's choice) as well as contain some of the theoretical background of the exercise and motivation for it. The purpose was to provide further incentive to the students to do the exercises (in particular to the strategic learners), to increase the congruence of assessment and thus to avoid the previously described 'backwash effect'.

[3] My experiences with the shift to online teaching are reported elsewhere (Wilhelm, 2020).

[4] Other course elements I included to improve more general aspects of the course – such as one-minute evaluations (see Stead, 2005 for a review), LaTeX'ed lecture notes, buzz groups during the lectures, video recordings of the lectures, a survey on the students' background, interests and plans as well as a limited experiment with flipped classroom – have to be omitted due to space limitations.

[5] This exercise-based exam is a type of assignment-based exam, similar to the one discussed in Grønbæk and Winsløw, 2004.

**Thematic exercise sheets.** Together with my TA, we designed seven exercise sheets which were based on one topic each, including a lot of motivation and background as well as references, and guiding the students through that topic using four questions. The length of the exercise sheets ranged between 3 and 8 pages. In particular, the exercise sheets were not about doing small steps left out in the lecture; those I made into in-lecture exercises. Instead, the exercise sheets were teaching units on their own, and some topics were only covered on the exercise sheets. In order for the students to see how lecture and exercises fit together, I referred to the exercises in many places in the lecture, also summarizing their results. In the other direction, the exercise sheets referred to the lecture in many places. In terms of intended learning outcomes, my intention with the exercises was to teach skills, whereas the lecture was more about knowledge. Based on student feedback, I also provided bonus exercises starting from the fourth exercise sheet. They were intended as a way to challenge themselves for the very few students who thought the regular exercises where a bit too easy, cf. appendix A, figure 4; the bonus exercises were not discussed in the exercise sessions, though.

**Supervised exercise solving sessions.** I uploaded the exercise sheets each Friday, together with an Absalon announcement giving a brief introduction and motivation to the exercise sheet. I instructed the students to make an attempt to solve the exercises before the one-hour supervised exercise solving on Tuesdays, where the students could receive help from each other and from my TA and me. During this hour, the intention was to get them unstuck when they were stuck instead of the students looking at the sheet for the first time.

**Office hours.** Wednesday morning, I had one hour were I guaranteed to be in my office so the students could ask me questions on the lecture, the exercise sheet and the course as a whole. I also encouraged the students to pass by my office at other times, but could not guarantee that they would find me there. Moreover, I encouraged the students to use an Absalon discussion group for each exercise and to write emails with questions.

**Quizzes.** I spent the beginning of each three-hour exercise session on Thursdays with a written quiz on important facts and formulas of the course. The printed-out quiz sheet contained 7-8 questions, which I selected based on what I think is essential to take home from the course, but also what is necessary to follow the following lectures. After the students had enough time to answer the questions (roughly 10 min, but I went around to look at their sheets and also ask how much time they need), I wrote the

answers on the blackboard and asked them to self-assess anonymously on a sheet of paper which of their answers were “Correct”, “Semi-Correct” and “Incorrect”. If a certain number of students had selfassessed their answers to a question as “Incorrect”, we included this question in the next quiz.

**Student presentations of the solutions to the exercises.** The bulk part of the three-hour exercise class on Thursdays was spent on student presentations of the solutions to the exercises, one presentation for each of the four questions. The students were encouraged to sign up for presentations the day before, the intention being to allow the students to prepare also mentally for giving a presentation and thus making them more likely to present. In particular, the student presentations were supposed to include also the motivation, background and context for the exercise, which was particularly important since some topics were only covered in the exercises. The presentations were supposed to last no more than 15 minutes, which was not imposed though. The other students were encourage to ask questions during and after the presentation, and there was usually a lively discussion between the students. I communicated to the students that the presentations are a valuable learning opportunity to practice presenting – for their future careers but also for the exam, since the intended exam format also was a 10-15 minute presentation on the exercises followed by questions. The aim was to split the group into two parts and have parallel presentations by two students with half the audience size. Thus, more students have the opportunity to practice presenting, and at the same time the smaller group size made for a safer learning environment and more lively discussions. I moderated one group, and in the cases that we could split up the group, my TA moderated the other one.

**Peer feedback on the student presentations.** An important aspect of the student presentations was peer feedback. As a preparation for the peer feedback, I let the students read a guide to giving and receiving feedback (Boud, 1991). Moreover, I asked the students which three points in the guide they found most important, surprising or hard to follow, and why. The feedback itself was based on six criteria, which I developed together with the students following Topping, 2009. Concretely, I presented the students with my proposal for the criteria in the first lecture, asking to discuss whether they adequately reflected their understanding of what makes up a good presentation. Based on their further input, I compiled a feedback form that we used for the student presentations. (After three weeks, I also let the students evaluate this form and made some adjustments for the rest of the course based on this evaluation.) After each student presentation, I asked

the students to take roughly five minutes to fill out the feedback forms. I then asked them to share their feedback, giving oral feedback in the plenum. In cases where I had the impression that an important aspect was not covered in the feedback, I prompted the students to share their thoughts on that aspect. In most cases, the peer feedback covered all aspects I though of, though, and some more. After the oral feedback, I invited the students to also hand their filled-in feedback forms to the presenting student. While feedback is beneficial to the receiver, giving peerfeedback is also beneficial to the giver of feedback, by clarifying the evaluation criteria and giving positive and negative examples; see e.g. Chanski and Ellis, 2017.

**Two hand-in exercises with written feedback.** The 3rd and 6th exercise sheets were voluntary hand-ins, an opportunity for the students to receive written feedback on their solutions to all four questions on each of the two sheets from my TA and me. I stressed to the students that the purpose of the hand-ins is not to grade them (such that they feel no need to perform), but to give them constructive and formative feedback; in particular, I encouraged the students to ask questions in their hand-ins on points that were unclear (instead of glossing over them), which was made use of by many of the students. While reading the hand-ins and giving the written feedback took a considerable amount of time, it also provided me with valuable feedback on the students' learning progress.

## Evaluation of the different course elements

In order to evaluate the perception and effect of the various course elements described in the previous section, I used a combination of attendance (see figure 2), participation (see figure 3), quantitative surveys and qualitative surveys. The surveys consisted of evaluations of the exercises in the first three weeks as well as the course evaluation at the end of the course, where I supplemented the standard questions with 10 additional questions on various elements of the course (the full results of the latter, excluding free-text answers, are included in appendix B). Note that in particular attendance and participation, as well as the answers to several questions in the surveys, measure the accumulated effect of the course elements described in the previous section, as well as depending also on other aspects of the teaching.

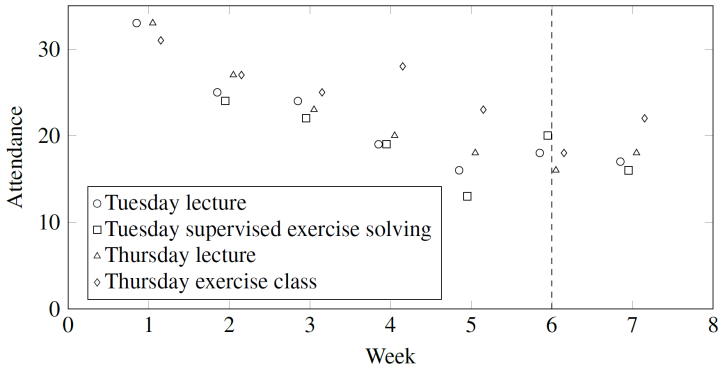


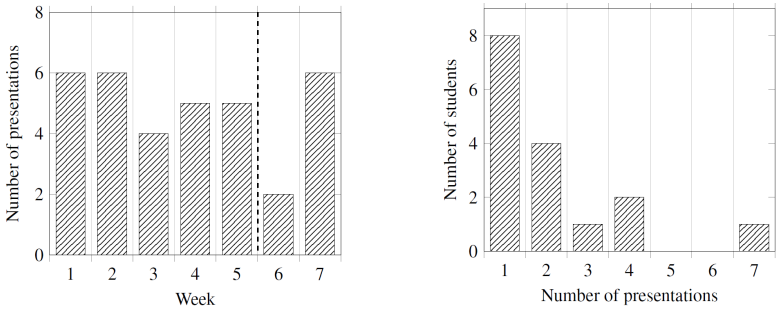

**Figure 2.** Attendance for the four main element of presence teaching throughout the seven weeks of the course. (Thursday of week 6 and Tuesday as well as Thursday of week 7: peak attendance in the online teaching platform "Zoom". Tuesday supervised exercise solving in week 1: data missing, but roughly two less than in the lecture. The start of the Corona-caused shift to Zoom is marked by a dashed line.)

The attendance in the two weekly exercise classes as well as the two weekly lectures is plotted in figure 2. As can be seen from this plot, the attendance in the exercise classes with supervised exercise solving is slightly lower than the attendance in the lectures, while the attendance in the exercise classes with quizzes and student presentations with peer feedback was on average higher than the one in the lectures. This indicates that the students perceived the exercise classes to be roughly as beneficial to them as the lectures.[6] This constitute a significant improvements over previous years.[7]

In the survey of the exercises in the second week, 63% of the students described the overall setup of the exercises as "very helpful", see appendix A, figure 5.

[6] A caveat in this interpretation of the attendance rates is that I provided lecture notes and video recordings of the lectures, but not of the exercise classes – allowing the students to benefit from the lectures without attending.

[7] How extensive this improvement is cannot be quantified, since only anecdotal data on the attendance in the previous years is available.




**(a)** Number of student presentations in each weeks. **(b)** Distribution of the student presentations.

**Figure 3.** Participation in the student presentations. (a) The exercise sheet in week 2 had only 3 questions, so we could split the group for all presentations, and even one student more signed up than could present. All other exercise sheets had 4 questions. The exercise in week 6 took place on the first day of the Corona shutdown in Zoom (indicated by the dashed line); we had two student presentations, but the solutions to the other two questions were presented by my TA. The exercise in week 7 also took place in Zoom due to the Corona shutdown. (b) In total, 16 of the 37 students attending the course presented their solutions to the exercises at least once. The plot shows how many students presented a given number of times.

**Exercise-based exam.** While a small number of courses use assignment-based exams, this is far from being the norm. Asking in the first lecture whether anyone had done an assignmentbased exam before and what their experience was, indeed a couple of students answered "yes" and reported good experiences, which probably helped in the renegotiation of the didactic contract. Indeed, the one-minute evaluations of the first lecture – in which I described the exam format, exercise format and format of the course as a whole – showed a lot of enthusiasm by the students. Despite of the multi-causality discussed above, it can be assumed that the exam type successfully contributed to the observed attendance rate in the exercises (figure 2), participation in the student presentations (figure 3) and the number of students handing in their solution to the two voluntary hand-in exercises. In the exam part of the course evaluations, one student wrote "I liked the format, where the exams questions were directly related to the weekly exercises. It made the exercises feel important. Some courses have

a bunch of exercises and I can hardly get myself to look at half of them. So, I liked this format. Really good course, well done."[8]

**Thematic exercise sheets.** The exercise sheets were positively mentioned in the course evaluation at several points. Students wrote for example "I really like that the focus of the course is in the exercises. Personally I learn the most and feel more accomplished by doing exercises."

**Supervised exercise solving sessions.** It was my impression that the students came prepared and indeed asked many questions, keeping me and my TA busy for the whole time. Thus, I would consider the supervised exercise solving sessions in their present (reduced) duration time well spent, in particular since I gathered from the surveys of the exercises that they increase the willingness of the students to present their solutions two days later.

**Office hours.** Not many students actually used the offices hours, but I think it is an important signal to send to the students of being accessible (and it does not actually cost me much to offer them). Indeed, the office hours were positively mentioned in the course evaluations.

**Quizzes.** In the course evaluations, 61.1% of the students described the quizzes as "very helpful" and a further 27.8% described them as "somewhat helpful".

**Student presentations of the solutions to the exercises.** In total, we had 34 student presentations, see figure 3a. This allowed us to split up the group for 9 of a total of 27 questions, i.e. exactly a third of the time. The benefit of splitting the group on the safeness of the learning environment was remarked on by the students in the evaluation of the exercises. The students showed very mixed inclinations to present their solutions. In total, 16 different students gave student presentations during the seven weeks of the course. Figure 3b shows how the total number of student presentations was distributed among the students.

**Peer feedback on the student presentations.** Twenty students answered the three aforementioned questions on the guide to giving and receiving feedback, and I was positively surprised how elaborate and thoughtful the written answers by most of the students were. Throughout the course, the peer feedback was very constructive, positive and friendly. In

[8] Due to the Covid-19 pandemic, the exam format was changed by the institute and faculty leadership to a written exam, and only the re-exam (taken by three students) could take place in the originally intended format but via Zoom. Thus, quantitative data on the intended exam format is lacking.

the course evaluations, 100% of the students answered the question "Did we manage to create a safe learning environment, where you felt you were valued as a person, treated with respect, felt that you could ask questions without being judged and felt inclined to participate actively?" with "very safe". I believe that the reading and writing assignment on giving and receiving feedback had a major contribution to this. In the surveys and course evaluations, several students found the feedback process in the present form to be too time consuming, though, one student writing "My only 'complaint' would be the course has been a little evaluation-heavy, especially having an evaluation session after each student presentation felt a little tedious, and slowed the momentum of the sessions. The feedback as a presenter however was quite useful. I'm torn on this point, but maybe there's a way to make a more elegant/less time consuming peer-feedback session?"

**Two hand-in exercises with written feedback.** 23 students used this opportunity the first time, 17 the second time. In the course evaluations, 55.6% of the students said the written feedback they received on the hand-in exercises was "very helpful", 22.2% said it was "somewhat helpful" and another 22.2% answered "Don't know", presumably because they did not hand in a hand-in exercise.

## Conclusion

The evaluation showed that the different course elements making up the new format for the exercise classes were perceived as beneficial by the students, leading to an increased number of students making use of the increased offer of learning opportunities. I also believe that the new format had a significant contribution to the overall very positive course evaluation.[9] Thus, it provides a solid base for further improvements in the coming year,

[9] In particular, on the question "Overall, I find that the course has been useful", 73.7% of the students wrote that they "strongly agree", while the remaining 26.3% replied with agreement (to some not further specified extend). Moreover, 94.1% of the students "strongly agreed" with the statement "In my opinion, the lecturer took an interest in the students' learning outcome from the course." On the basis of the course evaluations the teaching committee has assigned the course to "Category A: Courses where the teaching has worked especially well and may be an inspiration to others".

aiming in particular to further increase the percentage of students giving presentations and to expedite the peer feedback process.

The format for the exercise classes described in this report could be beneficial for many courses in theoretical physics. In particular, the exercise-based oral exams could be a valuable alternative for courses currently using lecture-topic-based oral exams.

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# A Selected data from the surveys and the course evaluation

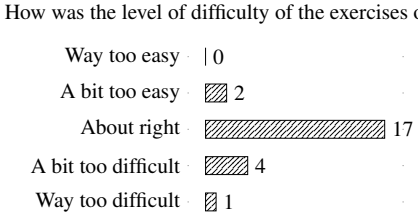



**Figure 4:** In total, 24 of the 37 students answered my question on the difficulty of exercise sheet 2, which I asked at the end of week 2. The distribution in the answers shows the full Gauß curve of differences in the students backgrounds.

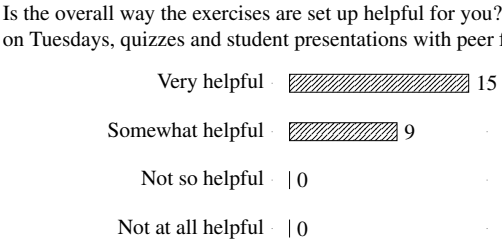



**Figure 5:** In the survey on the exercises in week 2, 24 of the 37 students answered my question on the overall setup of the exercise classes.

# B



**C Evaluation of specific course elements**

37 could answer this evaluation schema.
18 have answered this evaluation schema.
The answer percentage is 48.65%. : 18 / 37

**1**

1.1 Did we manage to create a safe learning environment, where you felt you were valued as a person, treated with respect, felt that you could ask questions without being judged and felt inclined to participate actively?

| | | |
|---|---|---|
| *Very unsafe* | 0 | 0.0% |
| *Somewhat unsafe* | 0 | 0.0% |
| *Somewhat safe* | 0 | 0.0% |
| *Very safe* | 18 | 100.0% |

1.2 Were the short in-lecture exercises and discussion groups on unclear points during the lecture helpful for understanding the material?

| | | |
|---|---|---|
| *Not at all helpful* | 0 | 0.0% |
| *Not so helpful* | 2 | 11.1% |
| *Somewhat helpful* | 4 | 22.2% |
| *Very helpful* | 12 | 66.7% |

1.3 How helpful were the lecture notes in clarifying which material is covered in the course and as guide for further reading?

| | | |
|---|---|---|
| *Not at all helpful* | 0 | 0.0% |
| *Not so helpful* | 1 | 5.6% |
| *Somewhat helpful* | 3 | 16.7% |
| *Very helpful* | 14 | 77.8% |

1.4 How helpful was it that the lectures were video recorded?

| | | |
|---|---|---|
| *Not at all helpful* | 1 | 5.6% |
| *Not so helpful* | 2 | 11.1% |
| *Somewhat helpful* | 9 | 50.0% |
| *Very helpful* | 6 | 33.3% |

1.5 Were the unclear points brought up in the one-minute evaluations after each lecture sufficiently clarified in the lecture notes and in the recap during the next lecture?

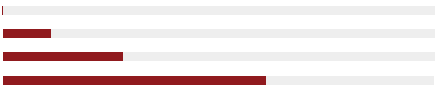
| | | |
|---|---|---|
| *Not really* | 0 | 0.0% |
| *To some extent* | 2 | 11.8% |
| *To a large extent* | 8 | 47.1% |
| *To a great extent* | 7 | 41.2% |

1.6 Were the improvements you suggested in the one-minute evaluations considered seriously, being either implemented or, in the case that they were not implemented, was it sufficiently explained why they were not implemented?

| | | |
|---|---|---|
| *Not really* | 0 | 0.0% |
| *To some extent* | 1 | 5.6% |
| *To a large extent* | 2 | 11.1% |
| *To a great extent* | 15 | 83.3% |

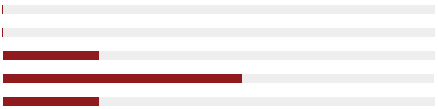
1.7 How helpful were the quizzes in clarifying what the core formulas of the course are and in learning them?

| | | |
|---|---|---|
| *Not at all helpful* | 0 | 0.0% |
| *Not so helpful* | 2 | 11.1% |
| *Somewhat helpful* | 5 | 27.8% |
| *Very helpful* | 11 | 61.1% |



1.8 Was the written feedback you received on the hand-in exercises helpful?

| | | |
|---|---|---|
| *Not at all helpful* | 0 | 0.0% |
| *Not so helpful* | 0 | 0.0% |
| *Somewhat helpful* | 4 | 22.2% |
| *Very helpful* | 10 | 55.6% |
| *Don't know* | 4 | 22.2% |



1.9 Did giving and receiving peer feedback help you clarify the criteria for good presentations?

| | | |
|---|---|---|
| *Not really* | 2 | 11.1% |
| *To some extent* | 2 | 11.1% |
| *To a large extent* | 8 | 44.4% |
| *To a great extent* | 6 | 33.3% |