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Improving report writing qualities with peer review feedback

Lise Bech Christensen

Dark Cosmology Centre, Niels Bohr Institute, University of Copenhagen

Introduction

In astronomy research as well as physics, we are constantly evaluated by peer-review procedures. In the course of the carrier, any graduate will encounter several if not all of the following review processes: project proposals and white papers, grant applications, job applications, paper writing and refereeing, or instructions and information for peers (e.g. sharing results through reports, programming codes and other documentations). Writing effectively entails describing objectively, clearly, while highlighting the crucial points in relatively short texts. Developing such competences is fundamental in getting a successful outcome with the intended purpose of the writing.

It is therefore important that undergraduate students become familiar with the entire process of how peer-review works in practice. Cho & MacArthur (2011) test the effectiveness of report writing for undergraduate physics students, and find that the process of reviewing other peoples report improve the students own writing skills. In a related study, Cho & MacArthur (2010) find that receiving feedback from multiple peers is more effective than from a single expert.

Inspired by these studies, I wanted to test if a similar procedure can improve astronomy students report writing qualities in the course I am teaching. The intended learning outcome is that the students learn to write such that others easily understand what they have done, explain why those steps were necessary, and finally explain the results, and how reliable these re-

sults are. In writing a report, they need to consider what should and should not be included in the report to keep it consistent, and yet sufficiently short.

My assumption is that a peer-review feedback session will benefit their future carrier whether or not they continue their carrier in research. I also expect that they have not previously experienced that a large written report based on several weeks worth of work is evaluated by their peers.

Course description: Astronomical Data Processing

The peer-review session was implemented in the course "Astronomical data processing" which ran in Block 3, 2013. This is a masters level course which I have developed and which is offered for the first time and is aimed at fourth year astronomy students. I am teaching the course as co-course responsible with a colleague, Marianne Vestergaard. Twelve students completed the course.

The course is aimed at astronomy students who wish to get experience with handling astronomy data in practice. The students work with archive data on their computers in lab style classes thus acquiring the functional knowledge necessary for an observational astronomer. The course does not include measurements at the telescope, because it would be difficult to implement in practice. The main focus of the course is practical work where the students have to process all the data themselves step-by-step using basic principles, instead of relying on black boxes, which are becoming standard in astronomy. Such black boxes are extremely fast and are sometimes necessary when dealing with a huge amount of data, but without a detailed understanding of the processes also prone to errors. Many procedures have to be carried out before any final analysis of the data can be done. This course aims to equip the students with a fundamental knowledge with simple data sets, such that they independently can start analyzing more advanced data products, e.g. if they choose an observational project for their masters thesis.

Course contents

- Class hours: 8 weeks, Mondays 13-17 and Wednesdays 9-12 + 13-17.
- Students are required to participate actively in class and be present more than 80% of the time.

- Introductions (20-30 minute lectures incl. discussions) to the various calibration data that are needed before even starting to analyze scientific data.
- Ten computer exercises on imaging and spectroscopy, starting from the basic introduction to the software used, to more advanced methods of handing data and error propagation. Discussing practical planning of observations. Calculating signal-to-noise ratios from basic principles.
- Roughly one hour sessions each course day with validation of their exercise results, and institutionalization.
- Students write two reports based on the first five exercises. The first report on imaging data processing and calibration will be peer-reviewed. The final report will include both imaging and spectroscopy, and will be evaluated by the lecturers.

The last step differs from what is stated in the course description[1]. Officially, the students are only required to submit a single report at the end of the course. However, given my expectation that their final report would be substantially longer than anything they had ever written[2], it would be better to split the report in two, and make the first part be peer-reviewed. Aside from spreading out the work load needed to write the report, I expect that a formative assessment of the mid-term report will benefit the students, because formative assessment is known to promote student learning Yorke (2003). At the beginning of the course, we asked the students if they agreed with splitting up the report in two parts, and the first being peer-evaluated. All students agreed to participate in this experiment.

Implementing peer-reviewing

The simplest cases for implementing of peer-reviews are when the task to review is a simple calculation exercise with a single correct answer. Alternatively, peer-reviews can be useful for topics of discussion, where various points of view can be taken and where diverse arguments are needed. For the course I taught, we deal with a combination of the two: One can make several assumptions while choosing a specific parameter in the programs

[1] The official course description is found here: https://sis.ku.dk/kurser/viskursus.aspx?knr=147123

[2] Their final reports varied between 50–70 pages in length including figures and appendices.

and reach some numeric results. These results may change slightly with the chosen parameters, but generally the final numbers have to agree within the measurement uncertainties if the correct error propagation is used.

In order for the students to learn from the peer-review process, they need to first know the criteria for evaluating the reports. As they have little prior knowledge with such a task, preparing them well is a necessary step. The information the students need can come from an evaluation rubric, or a sheet containing the correct results. I chose consciously not to provide them with a result sheet, because I wanted to check if they were able to spot mistakes in each others reports. I also did not want them to get the idea that the choices of parameters I had made was the absolute and best ones. Instead I provided them with some suggestions of what constitutes a good report, and what a reviewer would look for in a good report (Appendix A).

The peer-review process followed a structure according to the theory of didactical situations (TDS): A *devolution* where the students are informed of the process steps and a guide for their evaluations, followed by an *action* part where the students read another report, a *formulation and explanation* part where the groups consider the report and discuss what two write in the peer-review report, a *validation* where all the students present their peer-reviews reports for 5 min in front of the class, and finally an *institutionalisation* part, where I summarise and generalise the feedback and comments from the students, highlighting what is good and bad in a report.

Process steps

Following steps were implemented for the review procedure:

1. Students write a report based on the initial 5 imaging exercises included midways through the course. The exercises are common for all students, but the choices of various parameters and final results are not necessarily the same. The report is written in groups of 2-3 collaborating people. Four groups of 2 or 3 people were formed, while two students worked independently.
2. Each group reviews the report from another group. This part is not anonymous.
3. Students write a one page summary of the review, and submit that on Absalon as a given task.
4. One class session is devoted entirely to discuss the outcome of the peer reviewing process. Each group presents a short 5 minutes summary of the review of the other groups report.

5. The listeners, i.e. those who did not either present or receive feedback, are requested to note down one single positive and a single negative comment from each presentation.
6. Institutionalization, where all positive and negative responses from all the 5 minutes summaries are written on the blackboard and discussed collectively.
7. The evaluation of the mid-term report is meant as a formative assessment of the students course work. After the peer-review process the students are requested to modify their report taking into account the peer-review comments and submit the corrected report for a summative assessment at the end of the course. The grading is passed/not passed.

Guidelines

To guide the students through the peer-review process, they were informed about the procedures step-by-step a week before the event. I suggested a few things to take into account when they evaluate the other groups report (see Appendix A). I suggested that they reflect on the differences from their own report with the mindset that they consider their own omissions and mistakes in their own reports. I also emphasised that by making positive remarks and suggestions in the peer-review report, it can be used as an opportunity to help others improve their reports.

Peer-review reports

The students were required to submit the peer-review report to Absalon. Typically, the contents of these reports followed well the suggested guidelines. The best reports contained positive feedback, negative feedback, and suggestions for improvements, while other reports did not provide significant suggestions for improvements. Some of the low-level feedback included that some caption text was missing, figure labels too small to read, or equations should preferably be numbered for easy reference. While this is important too, it would have been preferable to also get a higher level of complexity in the feedback.

Since the students had been working on the same tasks and thereby knew all the necessary steps, the peer-review reports were good at pointing out omissions, e.g. that other groups might have skipped a relevant issue to discuss, or forgotten to include a relevant number which some of the

exercises asked for. In a few cases, mistakes were discovered. In the questionnaire most students report that the feedback helped them improve their final reports (Questions 4-5 in Appendix B).

Students workload

The lengths of the imaging reports that the students had to review varied between 15 and 30 pages including figures and appendices. Two days before the review session, the students handed in the imaging reports.

On average they spent three to four hours to review the reports, which included both reading, commenting, and discussing in the groups how to present the review. According to the feedback from the students, they would have needed more time for the whole process.

Nine of the 11 students reported that they never before tried to review their peers writing. Only a single student reported a more than once trial of the peer review process; mainly volunteered ones for fellow students, e.g. while reading their bachelor project.

Students reflections

One of the general comments from the students (Appendix C) was that reading other reports provided them with new ideas for their own report, and made them think what constitutes a good report. If they remain conscious about the way they write and present results in the future, the intended learning outcome is fulfilled.

Reflections

During and after the peer-review process, I reflected on how the task helped the student learning, and what changes to the peer-review process are necessary for the future.

Peer review report quality

To help the students further in making reviews of better quality, they need a bit more guidance of what constitutes a good report. In this first trial, the students were often more focused on reviewing the form of the reports

rather than their contents. To avoid that next time the course is run, I plan to give them information on what to evaluate in particular in addition to the information presented in Appendix A. When scientific refereeing is done, we can apply some of the questions that are typically addressed:

1. Are the assumptions mentioned clearly?
2. Are the methods described comprehensively?
3. Are the results adequately emphasized?
4. Are the figures and tables sufficient and properly laid out?

According to the my written guidelines (Appendix A), I asked the students to check the structure of the report and that the layout was readable and understandable for a student with knowledge equivalent to a 4.th year student, and who did not follow the course. They considered those issues carefully, but did a less careful review of the more detailed contents and the actual results. Next time the course is run, I will emphasise strongly that they should evaluate the results, compare with their own results and try to understand why there were any differences. As an illustration, the students computed an uncertainty measurement using two different methods. Those uncertainties should have been more or less the same, but some groups found a factor of 2 differences, and claimed that this result was correct. They reflected on that in their report, but apparently did not carefully investigate where in their programs they had a bug, or even considered that the other group had the correct result (which they did). After examining their program codes for the summative evaluation, I discovered two common mistakes. Next time I will be more thorough giving them feedback on this part halfway through the course, so they can correct their mistakes for the final report.

Without presenting a result sheet to the students, I probably cannot expect them to check in the greatest detail all the possible mistakes. Some students preferred to have such a sheet, while others did not (Question 2 in Appendix B). According to Cho & MacArthur (2010), students learn more from peer-feedback than single expert feedback. If I as an expert provide them with all my detailed comments, it might be too much information for the students to absorb and understand the importance of. Besides, I might give them an impression that my choices of parameter settings are the single best ones, although I frequently stressed in class that often there are several equally good choices. Accordingly, I will not provide the students with a result sheet next time the course is given.

While the students generally followed the information on what a peer-review report can contain (Appendix A), it would have been desirable that they reach a deeper level of reviewing. However, given the 3-4 hours time the students have spent on the reviewing task, the results were quite acceptable. As some of the students commented (Appendix C) they would have liked to have more time for the task. I agree that the timing was far from optimal, so the next time the course is run I will plan that the student have a couple of more days for the task.

Changes in the final report

One of the requests in the peer-review procedure, was that the students implement the changes suggested in the peer-review report they received. In that process, I did not enforce or mention directly that I would cross check that they implemented those suggestions and corrected their errors. I presumed that this was self-evident, and I had trusted that they did that task.

At the end of the course, when the students had submitted their final reports, I could check what changes they had done. From the six reports received, three included substantial changes. The changes were modification to the report structure, corrections of previous omissions, and including more descriptions. Two reports had negligible corrections like change of font sizes on figures axes. One of these reports did in fact not require many changes anyway, because it was already sufficiently comprehensive. One group did not implement any changes whatsoever, even though the peer-review report pointed out a mistake in their calculation. If the students had implemented those changes, the final results would not have changed much. However, a mistake like that should certainly have been corrected even though it would take a few more hours of work. Next time the course is run, I will highlight the importance of addressing all the items in the peer-review report, read the peer-review reports and approach each group to stress clearly that they need to take specific comments seriously into account.

Group work

A couple of students had decided to work alone on the exercises during the entire course and in writing the report. I did not interfere with that decision, partly because I agreed that this was the best option for a couple of

students given that they were lacking behind the working schedule of the course. While reading their final reports, I noticed that they had made significantly more mistakes and had more omissions compared to those who worked in groups. Presumably, the students in this course learn a substantial amount from each other, and will be able to correct each others mistakes. For the peer-review process, the students who worked alone did not have the chance to read a report that was much more elaborate than their own. I only discovered that at the end of the course block.

Furthermore, the feedback from the students that worked alone (see last comment in appendix C and question 6 in appendix B), suggested that they did not get sufficient feedback, and the entire task of peer-review is better done as a part of a group. Next time, I will enforce that all students be included in groups, because it enhances their learning.

Student involvement

A general observation during the course was that the students did not exhibit a high degree of involvement in class. When asked a question, students would hesitate with an answer, and typically only a few hands were raised to indicate an answer. In contrast, in the peer-review session, all the students were presenting the reviews, and in the last part of the session they all participated actively. Since the students are more involved in the activity, this also promotes a deeper learning.

Student feedback

Generally, the students appreciated the peer-review session, apart from the students who worked alone. Most of the students (10 out of 11) agreed or strongly agreed that the peer-review helped them improve their reports. Given the overwhelming positive feedback from the students the peer-reviewing session is worth keeping.

Perhaps a bit surprising, the students did not consciously write their report in a different manner when they knew that the report would be evaluated by their peers (question 3 in Appendix B). In fact I had anticipated that they would be somewhat more careful in their writing. Therefore the social motivation (Biggs & Tang 2011, Ch. 3) seems to be irrelevant for the task.

One student remarked that since the report was read by peers, it gave a more easy feel to the task of writing the report. Such a positive atmosphere

is conductive to student learning and perhaps an equivalent to the 'Theory Y climate' (Biggs & Tang 2011, Ch. 3) where the student is trusted with their own learning.

One student mentioned that the 5 minutes summary in class was excessive, probably because everyone worked on the same tasks, so the whole process was a bit repetitive. Another student disliked the institutionalisation part of the peer-review session where I generalised all the responses from the 5 minutes summaries. While I agree that the institutionalisation could be skipped since it is simply repetition, I presume that some students do benefit from the summary, because they see clearly what errors are the most common ones. Seeing a summary-list on the blackboard with common errors and common positive things in the reports certainly help some student to have a better overview. In addition to the summaries of the students own comments, I could finalise the process by presenting them with my own opinion of what a good report contains. This would leave out any doubts for the few students who need a bit more certified evaluations.

On the negative side, the students agreed that reading the other groups report was boring, since they had carried out the same tasks themselves. It is not clear if we can avoid this sense of repetition for this particular course. Presenting the students with different data sets would be an option, but comparing the final results will then be impossible. In my point of view that is not worthwhile.

Discussion and conclusions

As presumed, the students do not have much previous experience with peer-reviewing procedures. My initial aim was to test if the report writing quality had markedly improved by the peer-review procedure, but the notion of writing quality is subjective. What we can measure is the quality of the feedback given by the various groups and the changes implemented for their final report. While all students did provide suggestions for improvements of the other groups reports, the level of complexity of the feedback can be improved. Yet, what I mean here is at the level of an expert reviewer, and according to recent studies Cho & MacArthur (2010), students learn less from expert comments and more from multiple peer comments. As implemented here, when the students work in groups, they essentially get responses from multiple peers.

Concerning the changes the students implement in their own report based in the peer-reviews, there can be some improvements since only half of the groups made substantial changes for their final reports. However, many students reflect that the entire peer-review process makes them think more carefully of what constitutes a good report. Reaching this level of critical thinking on their own writing fulfills one of the intended learning outcomes of the course.

Ideally, the peer-review process will reveal if the students improve significantly their writing from the initial imaging report submitted for the peer-reviewing task, compared to the final report, which besides the imaging part also contains the remaining spectroscopy part of the course. For some of the group reports, the spectroscopy part had significant omissions compared to a more thorough treatment of the imaging part. From this single experiment with peer-reviewing, I cannot conclude that the students did not learn to improve their writing for the future. More likely, the spectroscopy part contained much more mixed tasks and was not as coherent as the imaging part of the course. I conclude that from some direct feedback from one of our students after the course ended. Combined with a high work load for the entire course and finalising the report meant that that there was not sufficient time to streamline the spectroscopy report.

In the course evaluation on Absalon after the end of the course, a couple of students remarked that the peer-review part of the course was worth keeping. Following the positive feedback from the students, the study-board recommended that peer-reviews potentially could be implemented in other courses across the physics study as well. Apart from the time spent informing the students about the guidelines for the peer-review, as well as the one hour reviews and discussions in class, the teacher time spent on the task is minimal. Also the students did not spend too much time on the task (3-4 hours). If students are exposed further to this activity during their studies they will gain confidence in the task, which some of them seem to lack, even when presented with thorough guidelines. Still, the students show an increased involvement and are overall positive towards the process.

In conclusion, I think the peer-review task was successful and can recommend others to try peer-reviews as a teaching and learning activity.

A Information to the students

A week before we started the peer-review process, I informed the students about the procedures and time-line for the entire process.

I presented a few slides (Fig. 15.1) to guide the students, given my justified assumption that only few of them had any previous experience with such a procedure.

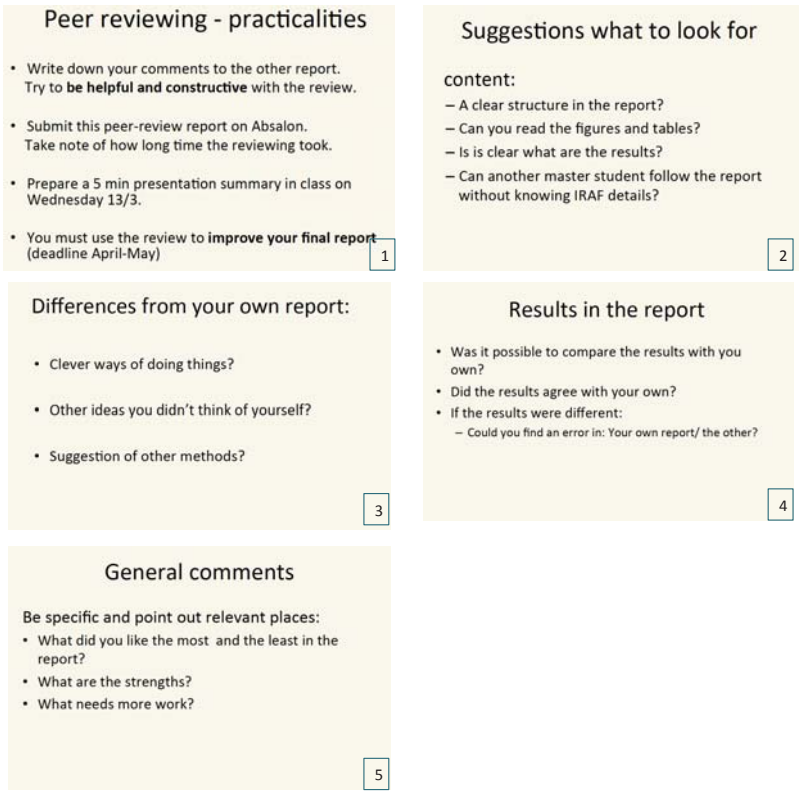

Fig. 15.1. Slides presented to the students before they started the peer-evaluation task.

B Statistics

The questionnaire for the students was constructed with very few questions, the first three of which were related to how they experienced the whole process and the last three on whether they benefitted from the process. Besides these questions the aim of the questionnaire was also to get feedback from individual students, as reported in Appendix C.

All eleven students who participated in the review session answered the questionnaire.

Questions

1. I got sufficient information how the peer-review process was going to be done
2. I would have preferred to have a checklist to help me reviewing other peoples reports
3. I was more careful when writing the report because peers had to evaluate it rather than the course teachers
4. The reviewers provided ideas how I could substantially improve my report
5. The whole reviewing exercise helped me increase the quality of the written report
6. I benefitted from working in groups rather than individually

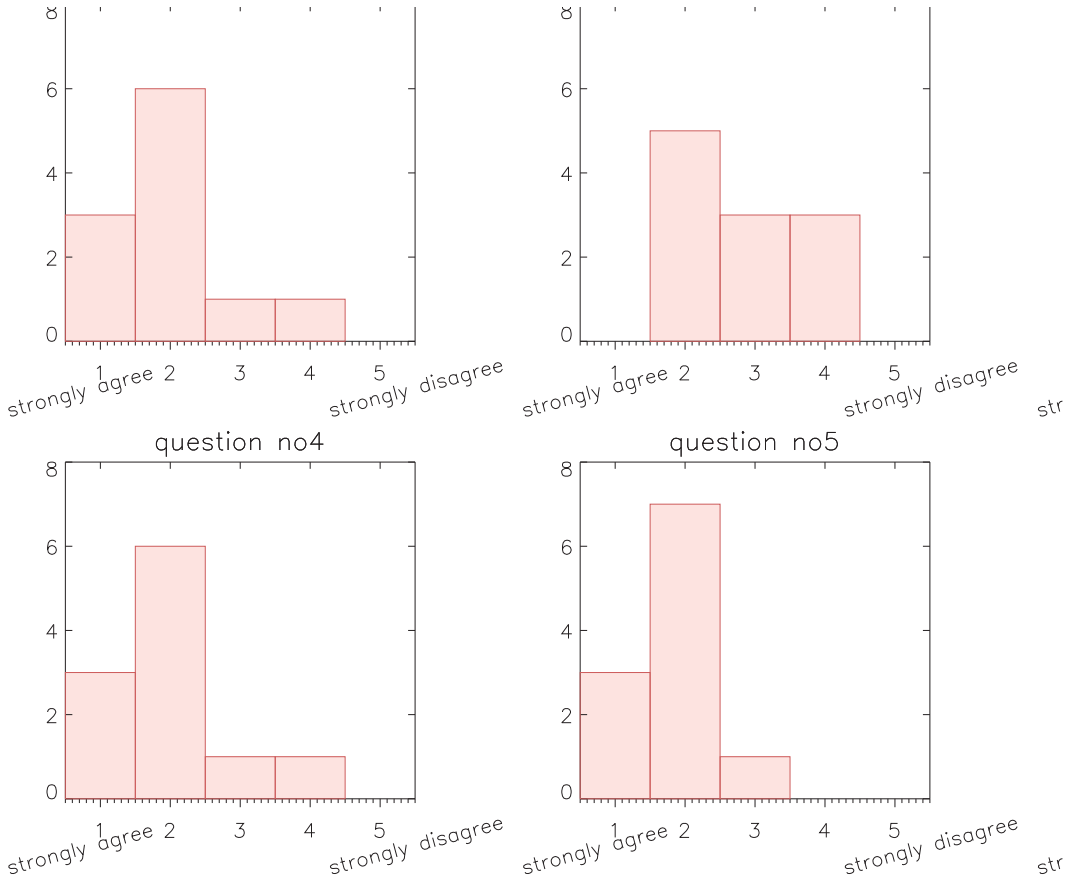

Fig. 15.2. Distribution of answers to the six questions in the questionnaire.

C Student feedback

This section reports the direct feedback from the students conception of the peer-reviewing procedures. The comments are partly translated by the author.

Question: What did you like about the whole peer-review exercise and what should be kept in a future version of the course?

- Good form of evaluation. Keep it an integral part of the course. It gives an easy feel to the report writing.
- It made me think more about what I think is a good report.
- The 5 minutes presentations were nice.
- It was good to have our results confirmed, and seeing that we did the correct things (Your reports were quite similar). Good to receive thorough feedback from the others.

- It was nice to see that the other groups had some of the same things to correct in their reports. I think peer-review is a good thing. It makes you think about how you could do some things differently in your own report.
- Quick and concise, makes it feel less negative.
- It was good to see how others had put emphasis on various aspects of the report.
- It was really useful because the other groups provided new ideas for improvements I would otherwise not had thought of. It was also really nice to have the peer-review session in class because we could see what the general tendency was for future reference.
- It was nice to try and it gave some ideas about improvements of the text. So it was a nice exercise but not strictly necessary.
- A lot of useful feedback and ideas to improve the report.
- The peer-review itself was good. Doing the review in groups brought new ideas to the table.
- The we were pretty conscious about what we ourselves would like to read in a report. Also that we got to split the report in two parts and get feedback on each part.

What did you not like, and what could be changed or improved?

- Maybe the teachers should also be involved in the reviewing process so there are some guidelines on how to do it correctly.
- A bit more time would be nice.
- It was excessive to report the review in class in front of the others. Instead we could have talked directly with the other group.
- It would have been great to discuss some more concrete issues related to the report, e.g. the errors of IRAF and our own errors.
- More emphasis on showing differences between reports needed. Maybe pick a few specific comparisons we have to show.
- It was very boring to read exactly what we had just written ourselves.
- It was a bit chaotic. I did not know at first that we had to submit a peer-review report. So get more structured for next year. Also, perhaps not as interesting to hear the same contents for all the reports, which was what I expected. More or less everyone made the same mistakes, and good things.
- Not necessary to summarize all the reviews in the end.
- I missed a formal description of the desired content of the report. There was very little time to do the review.

- Maybe have a day extra for the peer-review (hand in on Wednesday, and talk about it on Monday).

Course feedback

Listed below are the general comments from the students related to the peer-review session provided on Absalon after the course ended. The comments are partly translated by the author.

- I have gotten a lot of feedback from the peer-review session, which was a stroke of genius.
- The peer-review idea is really good, and should be maintained.
- I don't feel that I got much help from the peer-review session. I also feel that I didn't contribute as much as I could have for this either. Maybe it was because I worked as an individual and received feedback from the only other individual.