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Testing and evaluating peer assessment of chemistry exercises

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Background

During the fall of 2013, I taught a course called Nanotermodynamik, which is a basic chemistry course in the NanoScience program. I was responsible for helping the students during the exercise classes, correcting exercises and I also gave one lecture. Every week there was a set of exercises for the students to do. Most exercises were solved during a weekly session, where I was present to help the students. If some exercises were left, they were solved at home. The exercises were of varying difficulty; ranging from "plug-in-the-formula once you find the right formula" to more challenging exercises, including purely conceptual questions.

One of the more difficult exercises was to be handed in to the teacher. The normal procedure would be that I would correct these hand-in exercises and give them back to the students with some feedback. The exercises already provide opportunity for deep learning compared to traditional lectures, reaching primarily the lower three levels of Bloom's taxonomy (figure 22.1): Knowledge, comprehension and application (Alford et al. 2006). Classical lectures normally lie on the first and perhaps the second level.

The choice of exercises to be handed in has previously been chosen by the teachers in charge. They have taught the course before and have experience in choosing exercises of appropriate difficulty.

The project

I decided that my project in the *Adjunktpædagogikum* course would be to implement peer assessment of the chemistry exercises as an attempt to include even higher-level learning for the students compared to normal problem solving. The idea was to let the students assess (and thus be assessed by) someone at their own level. I decided that the form of assessment should be written constructive feedback and corrections to a student's solution of an exercise. I would then collect the exercises and give feedback as well.

In order for this to work, one important requirement was to have exercises that were suitable for peer assessment. This meant that the exercises required that the students needed to write down assumptions, procedures and calculations and that the exercise should be rather difficult, but still manageable to most students. I had a look at the exercises that were going to be handed in during the course and made the judgment that they were suitable for my purposes.

Motivation

The motivation for my choice of pedagogic experiment was two-fold:

- Students generally write for teachers, implicitly assuming that the reader knows more than they do. This can lead to poorly presented exercises that are difficult to correct. This approach to solving exercises is not beneficial for students in the long run. I believe that it is very important to be able to present your work well, and that it is a skill that should be acquired as part of your education. When writing for their peers, I hoped it would make the students present their exercises better, with more emphasis on complimentary figures and explaining text. Not only would this help the students in their learning and future career, but it would make my life easier when correcting the exercises. Assessing peers as well as being assessed by peers is also very common practice after graduation, in academia and in industry and is therefore a skill that should be familiar to the students.
- The second point is that peer assessment of other students' exercises allows for learning at higher levels according to Bloom's taxonomy (Figure 22.1), compared to just doing the exercises themselves. Even the highest level can be reached when assessing other students' solutions to exercises, in particular when the two students have found different solutions.

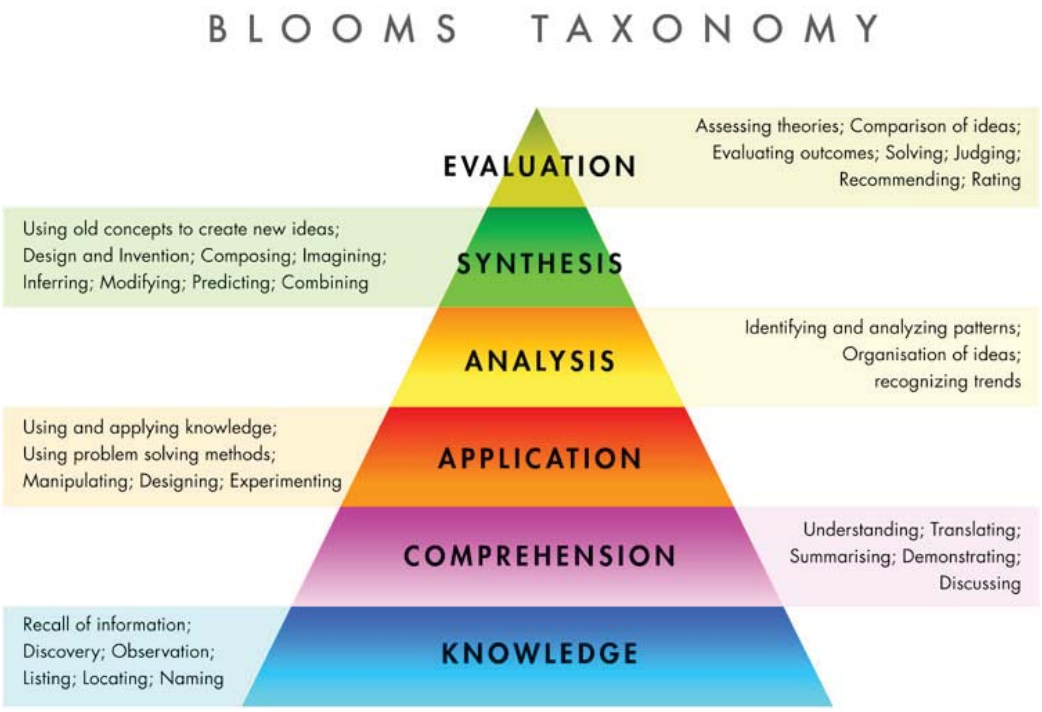

Fig. 22.1. The six levels of learning according to Bloom's taxonomy (Alford et al. 2006). The higher up the pyramid, the deeper the learning is.

Implementation

As mentioned previously, there was one exercise per week to be handed in. The teachers in charge chose which exercise, but I was able to provide my input and advice as well. The peer assessment was implemented for the first five weeks out of seven. The last two weeks, the exercises were handed in directly to me, without peer assessment, for practical reasons.

The distribution of exercises was semi-random. All exercises were handed in to me and put in a pile. The pile was sent back to the students, who were asked to take one exercise to correct and comment on, and pass the exercise pile on to the next student. Naturally, they could not choose their own exercise. The time allotted to the peer assessment was one week, and then the exercises were handed in to me for final corrections and feedback. The following week I gave the exercises back to the students, including comments on the feedback made during the peer assessment.

At the beginning of the course, I tried to help the students how to give constructive feedback. I gave examples of the sort: I would have appreciated a figure here… You could use some more explaining text… I also

mentioned that it is much more helpful to explain *why* there should be a negative sign on that number, rather than just stating that it is wrong.

Results

There were no objections raised when I informed the students about the experiment, and the peer assessment generally went well. I did feel that the peer assessment lacked organization, and one or two exercises were lost for some time before resurfacing when the student who had the exercise finally found it.

The solutions to the exercises were very well presented when compared to another chemistry course I taught at KU. Many exercises had illustrative figures, which are not normally seen in students' solutions to exercises. This was appreciated by the students as well and consequently led to very good assessments, where most students reacted positively and commented on figures, tables and explaining text.

In order to provide me with some more detailed feedback, I decided to evaluate the outcome of my experiment in the form of a written survey given to the students at the end of the course (before the exam...). The five questions that were intended to give me qualitative feedback were:

1. What did you learn from performing the peer assessment of other students' exercises?
2. Did you present your answer to the exercises differently when you knew your classmates were going to assess the exercises?
3. What did you like about the peer assessment?
4. What could be improved with the peer assessment?
5. Any other general comments?

Answers

I have assigned the students' answers to the first three questions as being positive or neutral/negative towards the peer assessment tasks. The quantitative summary is found in Table 22.1, and the results show that the peer assessment was well received and appreciated by the students, but that most of the students did not present their solutions to the exercises any differently than they would have if handed in directly to the teacher.

Question	Positive response	Negative/neutral response
1	13	9
2	7	15
3	15	5

Table 22.1. Quantifying the responses to peer assessment of chemistry exercises from questions 1-3 of the survey.

The full answers from the students can be found in appendix A. I have translated the answers that were in Danish into English for the sake of consistency.

Evaluation of the results

Many of my expectations and observations were confirmed by the survey. The pedagogic goals were largely met, as some students commented that they learned the course material better thanks to the peer assessment. Many also wrote that they learned how to present their solutions in a better way, which was also one of the project goals.

Fewer students than I had expected mentioned that they changed their way of writing the exercise when they knew that their peers were going to assess them as well. This is slightly at odds with the comments from question 1, which indicated that many students noticed how important a good presentation actually is and that they learned how to present their solution better.

The majority of the students liked the peer assessment. They mentioned that they learned more, and that it was fun and stimulating to assess and be assessed by peers. Only one student expressed severe discontent about the peer assessment.

The most occurring comment about what could be improved was that the organization could be better, which confirmed what I had noticed myself. A few students mentioned that it could have been better to assess a different question than the one they solved, while some liked to assess the same exercise they had solved, because they could compare solutions.

Actions for next time

It was quite nice to see that the survey answers agreed so well with my own observations. The main thing I need to change is to make the organization and handling of the peer assessment better. No exercises should be lost, and even if students misplace them, it reflects badly on the teacher. The learning outcome for the students improved, which means that the concept of peer assessment is very promising and should definitely be used as a teaching and learning activity again the next time I teach the course.

Based on my own observations and the students' survey answers, I have the following suggestions for improvements for next time:

1. The peer assessment has to be more organized. One suggestion is that the students can hand in directly to me, and I will copy or scan the exercises and hand out the copies to the students. This alleviates the problem of assignments getting lost. The feedback could then be done either online or directly on the copied assignment. I will also implement some kind of bookkeeping of who assesses whom, in order for the students to assess different people for each exercise.
2. All students assessed solutions to an exercise they had already answered themselves. I am going to try to divide the class into two groups and for some weeks give two different exercises to hand in, one for each group. Then the two groups will assess each other and the students have the opportunity to assess an exercise they have not solved themselves. In the evaluation we will then be able to compare what the students think is best – same questions or different questions.
3. In addition to the brief lecture when introducing the peer assessment, I will also hand out a written explanation of how to give constructive feedback for the exercises. This can help the students when performing the assessment.

Summary

I implemented peer assessment for chemistry exercises in the Nanotermodynamik course, which is part of the NanoScience program, where students had to give feedback on each other's exercises before handing them in to me for correction. While the implementation and organization could be improved, the peer assessment was well received. I made a survey after the course that showed that the students achieved deeper learning and how to

better present their work, which means that the main goals of introducing peer assessment were achieved.

A The students' answers to the survey

1. What did you learn from performing the peer assessment of other students' exercises?

Positive answers:

- It helped me remember the exercise a little better.
- I have learned be more elaborate when explaining my calculations.
- I picked up a few tricks in how to format homework in a more well-arranged way.
- Nothing much in terms of chemistry, but it was nice to get practice in evaluating other peoples work.
- I found out how to present a solution to an exercise in a nice way.
- I learned that even though the calculations are right, many small details can be missing.
- I learned from the methods (approaches) that they employed, i.e. explaining with text.
- It's nice to see someone else's way of answering the questions.
- I had a different look of the way to solve problems.
- A higher understanding of the material in the assignment. Having to correct another student's paper makes you think twice about the answers whether your own answer was correct or not.
- Not so much, but it was fun to see other people's solutions.
- Different way to do exercises, but they were in general too short to have big differences.
- I learned how important it is to write explaining text.

Negative/Neutral answers:

- There were only a few exercises made by a couple of people, and those were not too good. But practice helped.
- I wasn't sure anyway whether my own calculations were correct, so I had some difficulty in correcting other's exercises.
- Not so much. If the assignments are a little more complex I would learn more. It is about learning what's hard. The few assignments of the course were constructive.
- The idea is good, but not in practice. One corrects the exercise with one's own solution in mind. Therefore I learned nothing new.
- Not really anything. The ones I corrected were very similar to mine. But theoretically I could have learned different ways to approach the exercises.
- I found it difficult, because I was not sure my own answer and calculations were correct.
- 3 people stated that they had learned nothing.

2. Did you present your answer to the exercises differently when you knew your classmates were going to assess the exercises?

Positive answers:

- The answers had to be clear

- I found it nice to compare your own results and approaches to other students in the class. The results might be the same, but the approach can be different.
- It reflected some of the things I picked up from seeing others format, otherwise not.
- Slightly more explanation.
- Trying to keep a level of organization throughout the paper.
- I probably wrote more elaborately.
- I made a nicer layout and made my calculations clearer, as this was something I myself found important when assessing.

Negative/Neutral answers:

- No, I expected the teacher would also assess the same work.
- 14 people answered: No

3. What did you like about the peer assessment?

Positive answers:

- You see a different way to solve the same problem sometimes.
- Because it showed facit and how to solve the exercises.
- I like the help and exercises from teachers and I love Peer Wise.
- I picked up a few tricks in how to format my homework in a more well-arranged way.
- I liked getting some feedback on my work before it was handed in to the teacher. This way errors or misunderstandings could be fixed so I didn't have to hand in the exercise again.
- I found out how to present a solution to an exercise in a nice way.
- The possibility to see how details can vary.
- You could find alternative ways to calculate the exercises.
- The things you didn't know beforehand, and checking your own knowledge of the subject.
- It's nice to see someone else's way of answering the questions.
- A higher understanding of the material in the assignment. Having to correct another student's paper makes you think twice about the answers whether your own answer was correct or not.
- A different way to do the exercise, which was fun.
- That someone your own level corrects your exercises.
- One could see that one had the same idea for solving the exercise.
- It was nice to see other peoples way of thinking and different ways to solve the exercises.

Negative/Neutral answers:

- Honestly, not much… didn't really receive constructive feedback.
- I'm ambivalent.
- 3 people wrote: Nothing

4. What could be improved with the peer assessment?

- Had to hold on to others homework for a week when it only took ~10 mn to correct sometimes.

- It is difficult to know whether your exercise was corrected because you could not know if it was handed in to the teacher.
- Better feedback.
- It was a bit annoying that the one assessing your exercise didn't deliver it on time. It was therefore not listed as delivered and you would not get it back in time.
- Get rid of peer assessment.
- That the peer assessments are corrected by a teacher and not students, who forget to redeliver the assignments.
- I wasn't sure that your exercise was delivered for correction to the teacher.
- I didn't find it consistent enough. If it was to succeed it should be organized better. It needs a system that can be kept.
- The layout could be nicer.
- It should be more structured. It quickly got unorganized with what exercises you should deliver for others I yourself. It got mixed up!
- More structured way of delivering each others' exercises, as one can easily miss delivering the assessed exercise.
- Make it more controlled, so that you know if your exercise has been approved. More structure would be nice.
- Perhaps a full solution would be nice to use as a guide for assessing the exerices.
- Better organization to make sure which exercises were delivered. Even if an exercise had been delivered the teacher's notes could say not delivered.

5. Any other general comments?

- It is a bit risky to put the responsibility for your exercise to another student, if they misplace it, but altogether a very nice way to you're your exercises corrected.
- It was nice to se each others' exercises, but perhaps 15-20 minutes during class should be spent looking at each other's exercises and deliver it the same day to make sure it was handed in.
- Great idea, but keep it more consistent!

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