The blind leading the blind? Filling the knowledge gap by student peer assessment

K. Møllersen, *Department of Community Medicine, UiT - The Arctic University of Norway*

ABSTRACT: Prior knowledge in certain mathematical topics is essential for fundamental understanding of most STEM subjects, and closing the gap from secondary education is a prerequisite for success. The teacher's dilemma in higher education is the time dedicated to teaching secondary level maths versus the course's actual curriculum. To close the knowledge gap for a group of PhD students at the Faculty of Health Sciences at UiT, they were given a set of exercises to solve at home, and then did peer assessment in groups in the classroom.

This contribution presents pros and cons of active learning in the form of cooperative formative peer assessment exemplified in a two-hour math seminar. Although both students and teaching staff were positive, there are several risks to be considered. In conclusion, the math seminar succeeded in time-efficient assessment, but the final quality control is missing. The described balance between resources and quality can hopefully spark discussion within the framework of everyday higher education.

1. SCHOLARLY CONTEXTUALISATION

Two major components in education are prior knowledge and feedback. All higher education builds on some kind of prior knowledge and skills, mainly based on secondary school curriculum or prior university level courses. Successful teaching and learning rely on meeting the students at their skill level, making sure that knowledge gaps are filled. However, there are little to no allocated resources within the universities to fill those knowledge gaps, naturally so, since university level education institutions are concerned mainly with university level teaching.

In STEM education, prior skills in mathematics are essential for the students to succeed. As pointed out by Derr et al. [5], there is a need to close secondary school gaps before starting the curriculum, and the high heterogeneity in students' skills is a challenge. Filling the knowledge gaps with few resources relies on high student involvement, and delicately balancing the workload versus the students' learning outcome. Active learning has proven successful also in STEM education [7], and this opens the opportunity for the students to learn without the teacher to teach. Self-regulated learning and active learning can be seen as a duo, where self-regulated learning is a skill both necessary for success in active learning environments, but also a skill that can be acquired through active learning activities, see, e.g., [4] for self-regulated learning in higher education.

Feedback is essential to all learning, including self-regulated learning [3], and can be part of an active learning scheme through peer assessment. Whereas summative assessment (grades) is dominated by teaching personnel, formative assessment with its focus on learning through feedback is an arena where the contribution of peers is more common [1]. Formative assessment facilitates self-regulated learning identified by seven principles of good feedback practice [11].

Active learning is often organised as cooperative learning, defined as students solving a task together as a small group with active participation from each member [10]. Cooperative learning implicitly includes peer-to-peer teaching [13], especially with heterogeneous skill levels.

Successful learning relies on adequate prior knowledge, ability for self-regulated learning and proper feedback. To close the knowledge gap from secondary education that some students have, a cooperative active learning scheme including formative peer assessment and spontaneous peer-to-peer teaching has the potential to lay the grounds for successful learning in higher education.

2. AIM AND PROBLEM

At the Faculty of Health Sciences at UiT The Arctic University of Norway, the course *HEL-8047 Statistical models, conclusions and uncertainty for scientific data analysis* (7 ECTs), is offered to PhD students. Prior knowledge in certain mathematical topics is essential for fundamental understanding of statistical concepts, and closing the gap from secondary education is a prerequisite for success. The variety among health sciences PhD students regarding math skills is enormous: some need a slight brush-up; others never mastered mathematics and abandoned it as soon as possible.

To fill the knowledge gap, the students can participate in a maths seminar during the first week of the course. The maths seminar consists of student preparation by a set of exercises that the students solve individually at home, and a two-hour seminar where the students engage in peer-assessment with teaching staff present. The aim of the maths seminar is to give the students the opportunity to fill the knowledge gap in mathematics. Without resources allocated for the teaching staff, time spent on secondary level learning objectives steals time from the core subjects in university courses.

The main objective of this study is to describe this delicate balance through investigations on dedicated time and perceived outcome for both students and staff and offer insight into core pedagogical approaches through a real-life example. Pedagogical research describes and reveals contents and principles for successful teaching, but the resources needed to achieve success are too often ignored in the literature. An important contribution of this study is reflection around the pedagogical failures of the maths seminar, that can hopefully spark a discussion about which principles to prioritize, as opposed to which principles are better.

3. METHODS

The individual homework consisted of 33 short exercises focusing on fractions and equations, and 10 written exercises on probability. All exercises were at advanced 10th grade level. The students were provided with instructions of how to present a solution, and examples of solutions with adequate and inadequate step-by-step explanations. Students were encouraged to use Khan Academy for tutorials, and the exercises had matching key words for easier search.

At the maths seminar, the nine attending students organised themselves in two groups and exchanged homework, so that group A had the four individual homework of the students in group B, and vice versa, see Figure 1. The task was to assess the homework without access to solutions, so that the assessment relied on the combined math skills of the members of the group. At the end of the student assessment, each student got back their own homework with indications and additional comments. The thought behind this was for the students to assess the approach instead of right/wrong solutions, and to shift focus away from their own answers.

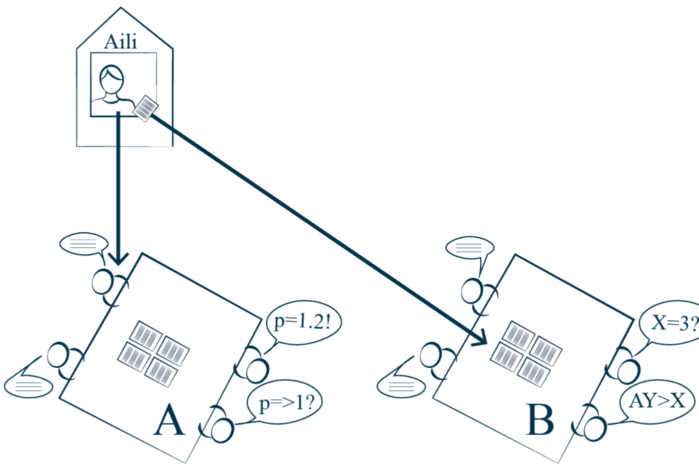

Fig. 1. Aili prepares by solving the exercises at home. At the math seminar, she is in group A, while her homework is assessed by the students in group B. CC-BY-SA-4.0. https://commons.wikimedia.org/wiki/File:Group_assessment.png

The choice to leave it all to the students came from the sheer necessity in the everyday teaching reality where resources are scarce. The background for choosing this form was to engage the students' self-regulated learning through active learning in the form of cooperative formative peer assessment. The individual components are described in Section 1 and provides a theoretical justification for success. To ensure some quality control, a teaching assistant (TA) was present during the seminar and could be engaged if the students needed some expertise. In addition, the last 10-15 minutes of the seminar was allocated to teacher-led explanations for exercises that students found difficult or could not agree on.

The study itself was conducted through assessment of three homeworks, observations in the classroom, interview with the TA, interview with four students (two from each group), and three questions in an anonymous questionnaire. Assessment of homeworks, observations and interviews were conducted by KM, the course leader and lecturer.

4. FINDINGS

The assessment of homework was done to investigate the actual math skills of the students, since the math seminar itself and the study relies on the target level being adequate. Of the three homeworks, two were very good (A or B) and one was catastrophically bad (fail), and in that sense reflects the hypothesis of heterogeneous skill level. All three students reported to have used 2-2.5 hours. The fail-student decided to engage in self-study and chose to re-do the exercises before the peer assessment session.

From the observations in the classroom, the students were actively discussing the exercises and solutions all through the seminar. They chose to work without a break for 90 minutes and managed to assess all exercises. The TA was actively engaged by the students.

The TA reported in the interview that the students asked for help as a group, had well-prepared questions, where they had already discussed different possible solutions, but could not agree on which was the correct one. Some questions were mere clarifications around concepts and words, but the majority were regarding correct or alternative approaches.

Four students were interviewed one by one. In addition to prepared questions regarding time and perceived outcome, the students were encouraged to bring forward any other thoughts and comments. The students reported to have used from two hours to "the whole evening" on the homework. All of them reported that the exercises where surprisingly difficult, knowing that it is 10th grade level. All of them reported to have used resources, either Khan Academy or old textbooks, but the extend of the use varied from a couple of exercises to nearly half of the exercises. The feedback regarding the homework swap varied; two of the students found it unproblematic, but the other two wished they could have their own solutions as well. One student found it intimidating that someone else was reading her solutions, that they would see how poor skills she has in mathematics. None of the four students reported a need to get the exercises assessed by staff after having it peer assessed. However, one of them found the received assessment rather useless, because of the absent of instructive comments. Two of the students reported in the interviews that they got to know the other students at the seminar through the group work, and therefore felt more secure, especially when asking questions. This was a spontaneous comment, and the two other students were not asked explicitly about this topic. Overall, all four interviewed students expressed satisfaction with the math seminar; they felt that it was useful.

Nine students responded to an anonymous questionnaire regarding the course, and a few questions were dedicated to the math exercises. Only four of the nine respondents completed the homework before the seminar and were asked the question: ``Did you find the maths exercises useful?". Three of them ticked the box ``Yes. Fairly easy, but nice for repetition.", one ticked ``Yes. Quite difficult, but important to learn." Three of those that completed the exercises also attended the seminar and were given the question ``Did you find the maths exercise seminar useful?", to which all responded ``Yes". The questions did open for comments, but none of the students commented further.

5. DISCUSSION AND REFLECTION

Before drawing any conclusions from this study, it is important to keep in mind that the number of students participating in this course is too low to generalise the findings in any statistically meaningful way. Implementation and use of a pedagogical tool requires balance between effort, results, and the uncertainty of the observed results. The uncertainty of the observed results is high, and the conclusions must be read as descriptions of the collected material.

From the interviews and assessment of the homework, it seems like minimum time invested by students are 2-2.5 hours for the homework. Then they spent two hours in the classroom for peer assessment and discussion. In sum, a clever student spends 4-5 hours. The teaching staff spent two hours in the classroom, and about three hours for preparations, in sum about five hours. Note that the five hours requires a ready-made set of exercises and does not include assessment and interviews.

The perceived outcome for the students was overall positive, with some suggestions for improvement, mainly structural. The main concerns regarding the math seminar before implementation were student discontent regarding the lack of expert assessment, or lack of dedication when solving the exercises beforehand and hence a break-down in the cooperative assessment. From the interviews and observation in class, students were content with peer assessment, but there is a potential for more students solving all exercises beforehand.

Engaging the students' self-regulated learning through active learning in the form of cooperative formative peer assessment can seem like a recipe for success, but there are shortcomings and pitfalls to consider, in general and for the math seminar in particular.

Students can be resistant to active learning [14] and peer assessment [9]. Although this study did not reveal an explicit resistance, it cannot be ruled out. Another aspect is that feedback can hinder learning, dependent on the students' prior knowledge [8]. With high heterogeneity, there is a risk for leaving the most capable students in a poorer state than before the seminar. One of the discontents expressed by a student was the lack of anonymity, as each student had their name on their homework. An easy solution is removing the names, but the size of the groups and the nature of the seminar hinders total anonymity, which has shown to have negative effects on peer assessment [12]. Although the students did express content, their perceived outcome is not necessarily in line with any objective outcome [6]. A major concern of the math seminar is the quality of the feedback [9], and there is a risk of ``the blind leading the blind", where student consensus contains incorrect answers.

Nicol and Macfarlane-Dick presented seven principles for good feedback practice [11]. Fulfilling them all are not feasible within a two-hour math seminar. The following discussion is whether the math seminar has the potential to meet them.

1. helps clarify what good performance is: Homework in the form of exercises was chosen specifically to meet this principle. Although specific learning objectives can be clarifying, it is worth keeping in mind that for example "addition" can be both the learning objective of an 8-year-old and the subject of a PhD thesis.
2. facilitates the development of self-assessment: Peer assessment can nurture self-assessment [9]. For the math seminar, peer assessment was chosen due to limited teaching staff capacity, and because peer assessment is part of the course later on.
3. delivers high quality information to students about their learning and
4. encourages teacher and peer dialogue around learning were absent from the math seminar. Learning mathematics is different from learning other subjects for PhD student at the Faculty of Health Sciences, but the math seminar, due to its limited time span, does not have a large potential for this.
5. encourages positive motivational beliefs and self-esteem: The students expressed in the interviews that the math seminar had both positive and negative effect on the self-esteem. Struggling with exercises that they knew were intended for 10th grade students had a negative effect, but working in groups and realising that also the other students struggle had a positive effect. Overall, they reported the effect to be positive.
6. provides opportunities to close the gap between current and desired performance: Working in groups has the potential of peer-to-peer teaching, and hence closing the knowledge gap. Although students were not instructed to teach each other, one student reported that this was exactly what happened.
7. provides information to teachers that can be used to help shape teaching: One of the key motivations for the math seminar is to get an understanding of the students' math skills. Through observations in the classroom, the teacher can get a good impression of the overall skill level.

The blind leading the blind?

The Condorcet's jury theorem (1785), see e.g., [2], describes the probability of reaching the correct decision through majority vote. With the right width of the knowledge gap, enough students in a group will reach the correct answer by themselves for the group to reach the correct answer. In this perspective, the described math seminar is not the blind leading the blind, but a project supported not only in pedagogical theory, but in probability theory itself.

REFERENCES

[1] Ashenafi, M.M. (2017), Peer-assessment in higher education – twenty-first century practices, challenges and the way forward, Assessment & Evaluation in Higher Education, 42:2, 226-251. 10.1080/02602938.2015.1100711

[2] Boland, P.J. (1989), Majority Systems and the Condorcet Jury Theorem Journal of the Royal Statistical Society: Series D (The Statistician), 38: 181-189. 10.2307/2348873

[3] Butler, D. L., & Winne, P. H. (1995). Feedback and Self-Regulated Learning: A Theoretical Synthesis. Review of Educational Research, 65(3), 245–281. 10.3102/00346543065003245

[4] Cassidy (2011), S., Self-regulated learning in higher education: identifying key component processes, Studies in Higher Education, 36:8, 989-1000, 10.1080/03075079.2010.503269

[5] Derr, K., Hübl, R. & Ahmed, M.Z. (2018) Prior knowledge in mathematics and study success in engineering: informational value of learner data collected from a web-based pre-course, European Journal of Engineering Education, 43:6, 911-926, 10.1080/03043797.2018.1462765

[6] Deslauriers, L., et al., (2019), Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom, Applied Physical Sciences, 116 (39) 19251-19257, 10.1073/pnas.1821936116

[7] Freeman, S., et al., (2014), Active learning increases student performance in science, engineering, and mathematics, Psychological and Cognitive Sciences, 111 (23) 8410-8415, 10.1073/pnas.1319030111

[8] Fyfe, E. R., & Rittle-Johnson, B. (2016). Feedback both helps and hinders learning: The causal role of prior knowledge. Journal of Educational Psychology, 108(1), 82–97. 10.1037/edu0000053

[9] Gielen, S., et al. (2010). Improving the effectiveness of peer feedback for learning. Learning and Instruction, 20 (4), 304-315. 10.1016/j.learninstruc.2009.08.007

[10] Krause, U., Stark, R., Mandl, H., (2009). The effects of cooperative learning and feedback on e-learning in statistics. Learning and Instruction, 19(2), 158-170, 10.1016/j.learninstruc.2008.03.003

[11] Nicol, D.J., & Macfarlane-Dick, D., (2006) Formative assessment and self-regulated learning: a model and seven principles of good feedback practice, Studies in Higher Education, 31:2, 199-218, 10.1080/03075070600572090

[12] Panadero, E., & Alqassab, M., (2019) An empirical review of anonymity effects in peer assessment, peer feedback, peer review, peer evaluation and peer grading, Assessment & Evaluation in Higher Education, 44:8, 1253-1278, 10.1080/02602938.2019.1600186

[13] Stigmar, M., (2016) Peer-to-peer Teaching in Higher Education: A Critical Literature Review, Mentoring & Tutoring: Partnership in Learning, 24:2, 124-136, 10.1080/13611267.2016.1178963

[14] Tharayil, S., Borrego, M., Prince, M. et al., (2018), Strategies to mitigate student resistance to active learning. International Journal of STEM Education, 5 (7), 10.1186/s40594-018-0102-y