Self-assessment of written exercises in STEM courses

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ABSTRACT: Students of physics in Norway typically spend a lot of time on mandatory problem-solving exercises that they must get a passing grade on to be allowed to take the exam. This is often a primarily summative assessment, which can limit the learning potential.

In this contribution, we present an intervention in which traditional mandatory assignments are modified to put more emphasis on assessment as a part of the learning process, by incorporating self-assessment and reflections about learning on the part of the students. The intervention was carried out in three basic subjects in physics at UiT in 2021 and 2022.

We will present results from the student evaluation of the intervention in two of the courses in 2022, discuss advantages and drawbacks and offer insights on future improvements.

KEYWORDS: Self-Regulated Learning, self-assessment, group learning, formative feedback, mandatory assignments.

1 INTRODUCTION

Physics students often spend a lot of time doing mandatory written assignments, and teachers spend much time writing detailed feedback on the student's submissions. However, in our experience, many students need to learn more from the activity. They may copy each other's solutions and not spend any time looking at the teacher's feedback if they get a "pass". Therefore, we want to change how we do assignments and give feedback by focusing on formative assessment and student self-assessment. By engaging in self-assessment, students can take ownership of their learning, set goals for themselves, and develop strategies for achieving those goals. Formative assessment provides ongoing feedback and support throughout the learning process, helping students identify areas where they need to improve and allowing them to address those areas. By incorporating more self-assessment and formative assessment into assignments, we can create a more dynamic and interactive learning environment that empowers students to take an active role in their learning and development.

Self-regulated learning (SRL) is a process where students actively engage in the learning process by setting goals for their learning, monitoring the process toward achieving those goals, and reflecting on their learning process (Zimmerman, 1986). Several studies have found a relationship between SRL and learning outcomes, though it is unclear what causes the effect (Jansen et al., 2019).

To support self-regulated learning through formative assessment, Nicol & Macfarlane-Dick (2006) propose seven principles for good feedback practice: including clear criteria; developing self-assessment and reflection in learning; encouraging dialogue with teacher and peers about learning; giving opportunities to use the feedback to close the gap to the desired performance; encouraging positive motivation and self-esteem and delivering high quality information to the student about their learning.

Student self-assessment describes various mechanisms and activities where students describe (and may evaluate) the quality of their learning process or products thereof (Panadero et al., 2016). It may be used instead of, or supplementing, feedback from the teacher. There are many ways to implement self-assessment. For example, Lovett (2013) created a reflection exercise around her exams, called an "Exam Wrapper", and Mota et al. (2019) had the students mark their weekly assignments in groups and reflect on their learning afterwards.

Here, we present an intervention in which we modify the traditional written mandatory assignments to include self-assessment, peer learning, and the students reflecting on their learning in two fundamental physics courses at UiT the Arctic University of Norway. We will present how we changed the assignments, some results from a student evaluation of the intervention and some thoughts on what worked well and what we want to improve in later iterations of the course.

2 METHODS

2.1 Description of the courses

FYS-0100 General Physics is a first-semester course that covers Newtonian mechanics, fluid mechanics and thermodynamics. FYS-1001 Mechanics is a third-semester intermediate mechanics course covering Newtonian mechanics, wave mechanics and special relativity. Both courses have three hours of lectures and one and a half hours of seminars each week, not including breaks. The lectures in both courses have mostly been replaced by different forms of active learning: Peer Instruction and Team-Based Learning, respectively. The students may also attend up to 4 hours of problem-solving workshops with a TA available for help.

The students in both courses are mostly physics students and pre-service secondary schoolteachers in physics and mathematics. FYS-0100 is typically taken in the first semester by 50-70 students and FYS-1001 in the third semester by 40-50 students.

2.2 The intervention

At UiT, students must pass a certain number of mandatory activities before they can take the exam. At the Faculty of Science and Technology, this often takes the form of several large problem sets that the students write up solutions to and submit for assessment by a teaching assistant (TA). The TA gives some written feedback on the product and marks it as passed or failed. The students often spend a lot of time on these problems (to the detriment of participating in other learning activities) and treat it as a summative activity (do not use much of the feedback in the later learning process). Four and two of these assignments are used in FYS-0100 and FYS-1001, respectively.

Motivated by these problems, we decided to make these activities more formative to increase learning (and decrease stress). Inspired by Mota et al. (2019), we added self-assessment and post-exercise reflection to the individual activity to involve the students in the feedback and practice SRL. Each assignment now has three phases:

1. The students get a problem set consisting of 3-4 problems that are more challenging than the weekly problem sets. These problems are first solved individually by the students, turned in, and graded based on whether they showed convincing effort. We tell the students to refrain from collaborating, but they can ask a teacher for help if they get stuck.

   It is unnecessary to get a correct answer to show convincing effort. However, the student should have attempted to solve all the problems using our suggested problem-solving strategy: trying to understand the problem (by drawing force diagrams, identifying knows and unknowns), devising a plan to solve it, executing the plan, and evaluating the answer (checking units, special cases and intuition). The teaching assistants will ideally spend less than five minutes grading this on a 1-3 scale.
2. The next day, the students attend a seminar where they self-assess their solutions in groups of 3-5 students. They are instructed to find and comment on any conceptual and procedural errors. The TA is available to answer any questions from the students.

   The students compare and discuss their solutions for the first hour without knowing the correct answer. Then, after about one hour (or if the discussion winds down), the TA hands out the instructor's solution and the students compare it to their solutions.

   The submission, with annotations and comments, is handed in at the end of the day or the day after. This annotated solution is graded on a 1-3 scale based on the degree to which students managed to identify their errors and show that they understand what they could have done instead.
3. After self-assessing their solution in the seminar, the students do a reflection exercise where they answer a few questions about what they learnt and what they are still struggling with on the topics included in the problem set. The reflection exercise consists of filling out an online survey form with questions about the students' learning outcomes from the problem set on the day of the seminars or the day after.

After trying out the intervention in the fall of 2021, many students reported that the reflection sheets could have been more helpful. Afterwards, we made a few changes to the reflection exercise, especially in FYS-0100, where we added a more specific question about the learning goals and questions about engagement and help-seeking to encourage the students to see the connection between their approach to learning and the result on the assignments. A pre-exercise reflection was also added to remind the student about what had happened previously and encourage goal setting.

The student's final grade (pass/fail) was based on an average of the grade on the individual submission and the marked submissions, and whether the pre- and post-exercise had been submitted or not.

2.3 Data collection

At the course's end, the students completed a survey about their thoughts and experiences doing the new mandatory assignments, including questions about the students' experiences with the individual assignment, the seminar and reflection exercise phases. There were also open questions to encourage the students to share their reflections.

FYS-0100 had 52 and FYS-1001 had 42 students that took the exam in 2022. In total, 70 answered the survey, and 23 students from each course agreed to let us use their answers for research.

3 FINDINGS

Our survey found that most students felt this way of doing assignments was effective in helping them understand what they had learned and what they still needed to work on (figure 1a) and that it was an efficient way to learn (figure 1c). Students prefer these assignments to the "traditional" way, but it is much more pronounced in FYS-0100 (figure 1b). This is the most apparent difference between the two courses on all questions in the survey.

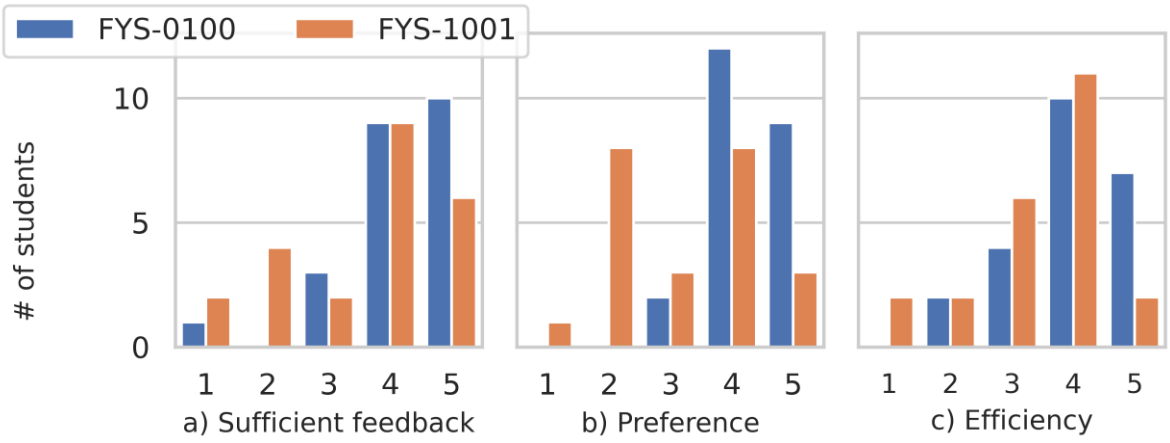

Figure 1: Student answers to the questions: a) "I understood what I had managed and what I had to work more on after marking my assignment."; b) "I prefer this form of written mandatory assignments over the traditional form."; c) "I had a good learning outcome compared to the amount of time I spent on the assignments". 1 is disagree completely and 5 is agree completely.

Figure 2 shows the typical amount of time the students reported using on the individual part of the assignment. Most students report spending around 10 hours (avg. 10.6h) on the individual part of these assignments. The activity requiring much time is a recurring theme in the student's responses to the open questions.

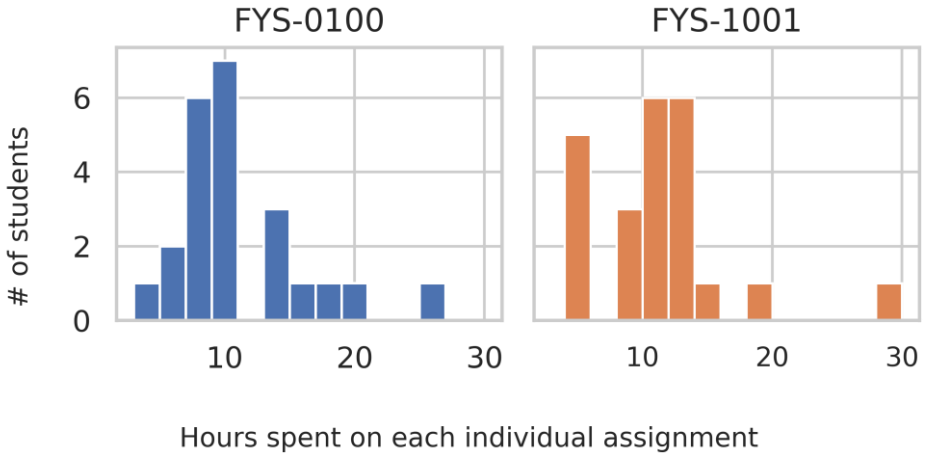

Figure 2: students' self-reported typical time spent on the individual assignments.

4 DISCUSSION

Most students in both courses were generally neutral or favourable to our intervention. They felt that they were getting the feedback they needed and learning efficiently. However, there was a marked difference in preference for traditional assignments among the students in FYS-1001 compared to FYS-0100. Is this because of differences in the implementations in the two courses, or has something changed with the students? Familiarity, for example, may play a part. The students are both more used to traditional assignments after a year at university, and there were fewer of these mandatory assignments in FYS-1001.

It is a concern that the students may spend more time on assignments than before the intervention. More than 10 hours on the individual assignment is higher than we aimed for, but we do not know how much time they used to spend on the traditional assignments. Adding to that workload, the students now spend at least two hours on the self-assessment and reflection, which they did not do before. On the other hand, one of the primary reasons for doing this in the first place was that students needed to spend more time on the feedback they got from the teachers. Also, students discussing with their peers and reflecting on their learning should lead to good learning outcomes. This is reflected in the results from the survey, where 63% of the students agree or strongly agree with the statement that they learnt a lot compared with the time required to do the activities.

In Norway, mandatory assignments are often used to control who is eligible for the final exam, based on the idea that students must demonstrate sufficient progress and understanding of the material by completing these assignments to show that they have a fair chance of success on the final exam. On the other hand, mandatory assignments can provide valuable formative feedback to students and help them identify areas where they need to put in more effort. Therefore, our approach has oriented the assignment towards the formative and away from the summative function since we do not grade the final product.

An often-overlooked challenge with traditional assignments is the time it takes for the teacher to correct the assignments and provide helpful feedback. By using self-assessment, with a group discussion and the teacher's solution manual, the students can find and correct their own mistakes. The TAs also report being able to spend as little as 15 minutes grading a typical submission, which frees up time for other activities. A good example could be providing additional feedback on the marked assignment, focusing more on the big picture without looking very deeply into the problem-specific details.

In addition to the assignment, the students turn in their reflections on their learning process. Simply answering these reflection questions is an exercise in evaluating and setting goals for your learning, which is an essential part of SRL. However, many students may need to be made aware of their learning process and how it could be improved. This was one important reason we tried to have more leading questions in the reflection exercise in FYS-0100 and added the pre-exercise reflection. We may also want to give feedback to the students on these reflections.

More generally, there is a question of what good quality feedback to the students is when they have already self-assessed their submission and reflected on their learning. Nicol and Macfarlane-Dick (2006) propose that good quality feedback is information that helps students troubleshoot their own performance and helps them close the gap between the goal and where they are currently. Some of the teacher resources freed up by having the students self-assess could, for example, be used to give feedback on the student's learning process and problem-solving strategies. Another possibility is to give some automatic level of feedback. For example, Carpenter et al. (2020) used the feedback mechanism in the quiz function of their LMS to deliver feedback on Exam-Wrappers in courses with many students.

In conclusion, the intervention engaged the students much more in the feedback process than our courses' traditional mandatory assignments. We plan to continue using this approach since most students accept this change. That said, there is still much room for improvement and questions to explore. For example, how often should we use self-assessment and reflection activities? SRL is a complex skill that is important for students to practice, and a larger "dose" could be beneficial. Therefore, we would consider using more self-assessment and reflection in weekly problem sets and other learning activities.

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