FORMATIVE ASSESSMENT AND COLLABORATIVE LEARNING IN A PREPARATORY COURSE FOR ENGINEERING STUDIES

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Abstract

This article contains a critical evaluation of how formative assessment and collaborative learning environments are used to enhance cross-disciplinary cooperation among pre-engineering students at the Preparatory Course for Engineering Studies at the Norwegian University of Science and Technology (NTNU). The article aims to evaluate how assessment of reflection, rather than assessment of correctness, may strengthen the connections between humanities studies and science and technology studies, and enhance the students' critical thinking. Further, an insight into the use of peer assessment and cooperative learning techniques at the Preparatory Course is provided as a means to highlight some further methods used to aid cross-disciplinarity.

Our desire to implement more forms of formative assessment and peer learning stems from the perception that university assessment tends towards the summative. Thus, each of the subjects involved with the Preparatory Course, Technology and Society (TS), English, Norwegian, Physics, and Mathematics, have decided on various forms of formative assessment and collaborative methods. Physics and Mathematics have shifted their focus from the traditional evaluation of correctness to assessing the students' ability to reflect on their own solutions and learning processes. The remaining subjects regularly use peer assessment of assignments, again valuing reflection rather than some notion of a correct answer.

Feedback from the students indicates that the implemented methods for many have resulted in an increased feeling of motivation and less test-related anxiety.

Keywords: cross-disciplinary learning, collaborative learning, engineering studies, assessment

1 BACKGROUND

This article provides a critical evaluation of how collaborative learning techniques and formative assessment are used to enhance cross-disciplinary cooperation among pre-engineering students at the Preparatory Course for Engineering Studies (PCES) at the Norwegian University of Science and Technology (NTNU). The article aims to evaluate how the use of self-evaluation as the primary factor to be assessed during compulsory assignments, as well as various collaborative learning methods, could enhance the students' capacity for learning and motivation. The subjects involved in PCES use self-evaluation, peer-learning and collaborative learning techniques to various extents. Thus, this article will produce an overview of how some specific methods are implemented in each subject.

This articles' primary motivation was to reflect on how the implemented assessment and teaching methods may have impacted the students' learning experience as opposed to more traditional and (arguably) more time-efficient methods. As a new national curriculum was implemented as of August 2022, it was a beneficial time to assess how different aspects of the PCES may have, both positively and negatively, affected the students' experience of the course.

The PCES consists of five different subjects: Norwegian, Technology and Society, English, Mathematics, and Physics. The course is conducted over two semesters, with final exams in all subjects. The structure of the preparatory course entails an intensive year for the students, with obligatory assignments in all subjects. The number of exercises varies in each subject, and the main purpose of these exercises is to provide students with practical insight into the theoretical concepts covered in the lectures. This is thus a central component of the students' learning process.

2 INTRODUCTION

The starting point for changing the feedback practices in the PCES was a desire for an assessment approach that prioritized learning over a summative assessment, specifically aimed at demonstrating acquired knowledge or a lack of it. Additionally, we wanted students to have even more opportunities to assess their own learning process in a constructive manner, helping them to identify areas that require further work. An assessment practice where students had to reflect on their own learning in different subjects would also provide them with a holistic perspective on the course. And through a more universal assessment practice, we hoped to achieve positive synergies from an cross-disciplinary focus. We will delve deeper into this in the discussion section of this article.

In the current year, we have had three different focus areas within assessment: reflection, peer assessment, and group work related to completed exercises. Briefly explained we aim for students to write a reflection following a test situation, where they assess their own performance as well as look ahead and plan further academic progression. Shortly after the exercise has been completed, the students are required to assess one or two responses from their fellow students. The group work and peer assessment are conducted in fixed groups which are formed at the beginning of the school year. The groups, which consist of 5-6 students, remain more or less constant throughout the year. This leads to a degree of predictability and safety which is important in assessment situations.

3 METHODOLOGY

In this section, we will present both the theoretical and practical aspects of each of the methods relevant to this article.

3.1 Self-evaluation

According to Rolheiser and Ross [1], self-evaluation could be defined as “students judging the quality of their work, based on evidence and explicit criteria, for the purpose of doing better work in the future”. Self-evaluation is a process in which students assess and evaluate their own performance, behavior, skills, knowledge, or progress in a particular area or context. It involves them taking a critical and reflective look at themselves to identify strengths, weaknesses, accomplishments, and areas for improvement. Through reflection and critical thought one can improve the quality of one’s own work and learning processes. Thus, if used in a conscious and constructive manner, self-evaluation could be a powerful technique used to enhance students’ self-efficacy and nurture intrinsic motivation. However, evaluation in and of itself is a rather complex level of cognitive thinking. According to Bloom’s Taxonomy it is the second to highest level of high order thinking [2] Thus, it is reasonable to believe that proper well-structured self-evaluation could be difficult for students to perform even with sufficient guidance.

3.2 Assessment of self-evaluation in Mathematics and Physics

Traditionally, Mathematics and Physics are often assessed using a summative score to a written test. During the last years there has been an increased focus on various forms of formative assessment that could be implemented in STEM fields. Examples of this could be automated formative responses using computer aided assessment, for example STACK [3], or project-based assessments [4].

At the PCES we have implemented assessment of self-evaluation, rather than assessment of “correctness”, as the primary form of evaluation. This is not a new change, as it was implemented quite a few years ago. However, this year (2023) we have given the topic of self-evaluation and reflection increased attention both in the humanities studies and the STEM-courses. Though some variations are to be expected from class to class, the general method is as follows; The students are asked to solve a problem set in a given time frame, usually 45 or 60 minutes. This problem set is based on the material from the previous weeks of teaching. Following the problem-solving session, the students are often asked to form small groups of four to five students, discussing their solutions and the problem set in general. This is done before the teacher’s solution to the problems is provided. Here the students are encouraged to orally explain their reasoning to their peers, and if varying solutions are presented, they are asked to collaboratively explore each solution. Following the peer discussion, the teacher presents a solution to the problem set. The students are asked to take notes and pose questions during the presentation. After each exercise the students are given time to write down a self-evaluation for that specific exercise. When the entire problem-set has been presented, the students are given ample time

to write a general reflection of their performance, both during the problem-solving session, and the weeks prior. As Physics is a more time-restricted subject (mainly 90-minute teachings sessions) the intermediate discussion may often be excluded in favor of more time for self-evaluation.

When the time comes for assessment, the teacher (or learning assistant if the class is sufficiently large) looks primarily at the student's self-evaluation, only referencing the student's solutions to assess whether the evaluations seem reasonable. I.e., if the students said they were not happy with their solution, the teacher could look at their solution and comment accordingly. Thus, it is possible to in theory get no points on the exercises, and still pass due to a well written and constructive self-evaluation. Guidance on how to write a proper self-evaluation is also provided to the students, both in forms of examples, and question guidelines the students can follow.

3.3 Peer assessment

There are several good reasons to use peer assessment in higher education. The article "Peer Assessment, Theory into Practice" [5] emphasizes cognitive benefits, improvement in feedback, enhancement in writing, and more effective group work as positive outcomes from peer assessment. In the current school year, we have had a dedicated attention to feedback and group work in our subjects, and in that regard, peer assessment can be seen as highly relevant.

There are several possible approaches to peer assessment, and in our case, the focus is on harnessing the positive effects of group work, providing prompt feedback, and leveraging the knowledge within the student group. Further it is important to us that feedback occurs shortly after the students have completed the exercise. This is however challenging for us as teachers to achieve, which again underlines the importance and benefits of peer assessment.

4 DISCUSSION

In this section, each of the previously mentioned methods, assessment of self-evaluation and peer assessment, will be discussed and evaluated in relation to both the student and teacher experience.

4.1 The impact of assessment of self-evaluation

As the implementation of assessment of self-evaluation at the PCES was done years ago, the grade specific impact is difficult to examine. However, as our students mainly have a high-school education, where traditional means of assessment is often used, we can explore how the students have reacted to the change of classroom and assessment culture. This can often be seen by how resistant the students are to the change, as students facing a radical alteration of the classroom culture may resist the change due to the cultural shock [6]

The most common attempt at self-evaluation, in the beginning of the year, is listing the steps taken to reach an answer, for example, "here I multiplied both sides of the equation by the common denominator in order to remove all fractions from the equation". The students seem to struggle with the difference with evaluation and explanation. This could derive from students' former experiences from school, where many experienced that their explanation of the process is more important than their answers. When they then are asked to evaluate their solutions, they default to explaining their process, rather than reflecting on their reasoning. Furthermore, being assessed on self-evaluation could be a rather vulnerable position for students. Being asked to point out their own weaknesses (and strengths) could possibly be seen as "a trap", where pointing out "the wrong thing" may result in a worse result or grade.

When the students get more comfortable with self-evaluating, rather than explaining, they are often overly negative. It looks like their concept of evaluation is tilted towards the negative aspects of their solutions, rather than the positives. However, this could be rather easily corrected, either by directly pointing out some positive aspects of their solutions, or by posing questions aiming the students towards a positive outlook on their progress. The high-achieving students often struggle more with this negatively tilted self-evaluation. When a student has correctly solved a task, they often struggle, or sometimes do not even try, to reflect on their solutions. Some even go as far as to say that "nothing can be reflected upon". It is among these high-achieving students that we can see the most resistance towards this form of assessment. Some have even expressed that they do not see the point of reflection when they "have solved everything correctly".

After some attempts, most of the students get a good concept of what is meant by self-evaluation. They write proper and well-structured reflections and indicate both the positives and what could be improved.

Further, some students lay out a plan on how to achieve their goals. When the students have gotten used to this form of assessment, their feedback on the method is generally very positive. They express a lessened feeling of test-anxiety and that there is room to learn. Overall, the students seem pleased with this form of assessment, as opposed to a more traditional form.

A downside of uniquely using this form of assessment is that the students rarely get a clear insight into how they are performing in the course (in relation to the final exam). To combat this, we have implemented two practice exams following the same structure of the final exam, one before the Christmas break and one around Easter. Here the students are not asked to write a self-evaluation. The practice exam is then graded in the same way the final exam will be graded, though this grade is only meant to be of guidance, thus it is not counted towards the students' final grade. Furthermore, each student is given ample feedback, either written, orally or both, to help them understand how they are performing in the course. They are often asked to perform some form of self-evaluation in their own time, particularly if their intermediate grade does not equal their expectations. Asking the students to reflect on their own is also an attempt to help the students implement self-evaluation as a personal learning technique, rather than something that they are "forced" to do.

Such extensive use of self-evaluations stems from a desire to help the students generate a complete picture of their studies through reflection of both their subject specific progression and their general performance. Many of the qualities gained through learning how to self-evaluate are vital for the humanities studies. Not only do the students get a chance to directly use what they learn regarding writing techniques; They also potentially elevate their critical thinking and ability to reflect, which are essential skills not only for learning purposes, but also everyday life. As self-evaluation and reflection have been taught all courses, either directly or indirectly, it is possible that some students may have had an easier time connecting each course with the others, and thus may have enhanced cross-disciplinary connections.

4.2 Peer assessment, group work and cross-disciplinarity

As the PCES is a composite program with several different subjects, we have a strong focus on cross-disciplinary learning, aiming for students to perceive the course as comprehensive. Previous years we have received feedback that the subjects are experienced as separate, and that the course instructors pay too little attention to the overall workload. By standardizing assessment practices and making them more similar across the various subjects, we hope to at least make feedback and post-exercise work more predictable.

Topping (2009) refers to Salomon and Globerson (1989) when highlighting certain common concerns about the implementation of peer assessment. He mentions, among other things, the risk of "negative social processes, such as social loafing, free rider effect, diffusion of responsibility, and interaction disabilities" [5]. In addition, teacher anxiety is mentioned to be a factor that possibly can hinder implementation. We have attempted to address these challenges early in the process. One of the measures is to contribute to accountability by having fixed groups, since the students know that they are to work with these group members over time and in several exercises. Additionally, it has been crucial for us to focus on creating awareness and reviewing expectations when it comes to peer assessment. By giving them a theoretical foundation about this form of assessment, it makes the process more predictable and helps the students understand their roles and responsibilities. However, we have still encountered some of the already mentioned challenges, and we see that established social relationships and roles can be reinforced and impact group discussions. This is something we pay extra attention to when implementing peer assessment in our subjects.

The feedback practice includes various elements that can be related to the different subjects taught in the PCES. The most evident element is perhaps communication, which is a central topic in both language subjects (Norwegian and English). Communication is an important element in both reflection and peer assessment since one must adapt the message to a given recipient. When the students reflect or assess each other in Physics, Mathematics and Technology and Society, they utilize their theoretical knowledge about communication acquired in the language subjects.

Feedback from the majority of students clearly shows that they are pleased with the use of peer assessment. They claim that this form of assessment and learning is one of the most constructive and productive learning techniques they use. Here we get an impression that it is the most active students, those who partake in most of the teaching activities, who appreciate this form of assessment the most.

Like self-evaluation, peer assessment can be seen as a cultural shock to most students, and thus the students who contribute the most to the classroom culture may get the best experience of such teaching techniques. Oppositely, the students who struggle to partake or accept the classroom culture may, either consciously or subconsciously, reject this teaching activity. Ultimately, this is yet another teaching technique that is highly student dependent. It requires student participation and collaboration to be of any use both for students, and for teachers.

5 CONCLUSIONS

The ever-ongoing process of renewal and improvement of our own assessment and teaching practices has inevitably yielded interesting results. Unsurprisingly, implementation of student-centered teaching techniques was both difficult and time consuming, but most importantly impactful and well-received by both staff and students. While the beginning phases of each year does require more attention and time from the teachers due to the expected breach of preexisting expectations of classroom culture, this could be somewhat balanced out by the increasing level of student independence as time goes on. Particularly, as the students learn to allow their peers to be both a social and academic resource through natural peer assessment, discussion, and collaboration. However, if these effects are not reached, allowing a course to be so reliant on student contribution, **social** interaction and positive mutual dependencies may be detrimental to the students' performance. This then requires vigilance from the teachers and constant reinforcement of a positive and inclusive classroom culture.

In this article we set out to explore how these methods could aid cross-disciplinarity at the PCES. The answer may lie in cross-subject connections between means of assessment and teaching. Each subject does in some way employ similar, student-centered teaching and assessment techniques. The qualities learned in one subject, i.e., critical thinking, self-evaluation, collaborative skills and so on, are easily employed in the next, thus making for a smoother and more seamless transition between classes. Thus, it is not in the subject specific aspects we find the most prominent cross-disciplinary tendencies, but rather in the fundamental qualities cultivated across courses.

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