ASSESSMENT AND FEEDBACK ACROSS VARIOUS OUTCOMES IN PROJECT-COURSES: A DEPARTMENT-WIDE STUDY

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ABSTRACT

Project-based learning plays a central part in many study programs in technology and engineering and have demonstrated success both in motivating students and promoting effective learning both of technical engineering skills and more generic skills related to teamwork and collaboration. Yet, especially the assessment of the more generic skills has been pointed out as challenging in research literature. It is therefore interesting to know how teachers think about feedback and assessment in their project courses, and whether they view any challenges in balancing the assessment of various learning outcomes pursued by project courses. In this study, 12 teachers from the same university department were interviewed. The purpose was to investigate what learning outcomes are pursued in their project courses, what approaches are used for assessment and feedback, and how do assessment and feedback practices prioritize between different learning outcomes? Findings indicate that there is more weight on the technical, engineering-oriented outcomes than the interpersonal communication outcomes, although this varies among the courses. Some of the courses emphasize reflection about the team process and how the members' communicative skills developed through the project, though there is no thorough assessment whether these skills improved during the project. This is in line with findings from international studies, indicating that interpersonal skills like collaboration are very hard to assess.

KEYWORDS

Project-based learning, Computing, Assessment, Feedback, Standards: 2, 5, 7, 8, 11

INTRODUCTION

Project-based learning (PjBL) plays a central part in many study programs in technology and engineering. Project courses provide a good arena for students to conceive, design, and implement engineering artefacts (Pee & Leong, 2005), and also to consider overarching issues related to ethics and sustainability (Bolstad, Lundheim, Strømberg, Orlandic, & Zimmermann, 2021). Not the least, projects give opportunity for so-called *dual use of time*, pursuing learning outcomes related to employability skills such as communication and collaboration while still achieving disciplinary skills previously pursued in more lecture-based courses (Edström, Gunnarsson, & Gustafsson, 2007; Leslie, Gorman, & Junaid, 2021; Winberg et al., 2020). Indeed, empirical studies have indicated that a switch to PjBL does not cause a loss of content knowledge, rather an increase (Ralph, 2016; Chen & Yang, 2019). At the same time, assessment in project courses is challenging. Guo et al. (2020) observed that project-courses have up to four different types of outcomes: cognitive, affective, behavioral, and artefact (related to the developed product) but that many of these outcomes tend to be assessed just by student self-reporting of perceived learning rather than any measurement of improvement from start to end of the course. Especially for collaboration and communication skills, one reason could be that they are hard to measure (Scoular, 2021), and teachers in engineering departments tend to be experts in the disciplinary content knowledge, not in more generic skills.

The Department of Computer Science at the NTNU is involved as a main contributor of courses in a dozen different degree programs, each having several project courses. Hence, there is a lot of variation in these project courses, both regarding the student group, and various aspects of the project course design (Sindre, Giannakos, Krogstie, Munkvold, & Aalberg, 2018). We wanted to look at the department's full portfolio of project courses in the light of the following research questions: **(1) What learning outcomes are pursued in the project courses? (2) What approaches do the project courses use for assessment and feedback? (3) What is the relative priority of the assessment and feedback practices when it comes to different learning outcomes,** such as disciplinary content knowledge (e.g., software design) versus more generic skills (e.g., communication and collaboration)?

The rest of this article is structured as follows: Section 2 presents some background on the department and its educational offerings, as well as some related research. Section 3 then explains our research method for this article, whereupon findings are presented in section 4. Finally, section 5 offers a concluding discussion on how to interpret the findings, and how feedback in project courses could be improved.

BACKGROUND AND RELATED RESEARCH

The Department of Computer Science at the NTNU, whose project courses are the target of this empirical study, is the second largest university department within the field of computing in Norway when it comes to person-years employed, and the largest in study credits produced per year. It is a main contributor of courses to the following study programs:

- Integrated 5-year master: Computer Science.
- 3-year bachelor programs: Informatics; Programming; Cybersecurity; Digital Business Development; Bachelor Engineering CS; Information Technology.
- 2-year master programs: Informatics, Applied Computer Science, Cybersecurity, Collaboration Technology, Healthcare Informatics.

Most of these programs are taught at the main NTNU campus in Trondheim, but two are taught in Gjøvik, two across campuses in multiple towns, and one fully online for remote students. In addition, the Master Healthcare Informatics is an experience-based continuing education program, students mainly working remotely but also participating in intensive gatherings in Trondheim. This plurality of educational offerings stems from the fact that the department (and NTNU as a whole) has grown through several mergers, thus having a combination of more academic study programs coming from the old university, and engineering-oriented programs from former colleges in Trondheim, Gjøvik, and Ålesund. All these study programs have several project courses. As an example, Table 1 shows the course composition of the 5-year integrated master program in Computer Science, which is offered in the Trondheim campus. Abbreviations in the table: CS1 is intro programming in Python, OO prog is object-oriented programming (Java), HCI = Human-Computer Interaction, and AI is Artificial Intelligence.

Table 1. 5-year integrated master, Computer Science at NTNU

Semester	Courses			
10	Master thesis			
9	Elective	Thesis prep theory	Master thesis pre-project	
8	Elective	Elective	Elective	Interdisc. proj
7	Elective	Elective	Customer-driven project	
6	Physics	Tech management	Elective	Security
5	Calculus 4	Elective	Intro to AI	Prog lang
4	Communication tech	Operating systems	Databases	Software eng
3	Statistics	Computer fundam.	Algorithms	Project 1
2	Calculus3	Electronics	HCI	OO prog
1	Calculus1	Discrete math	Philosophy	CS1

The third study year (semesters 5 and 6) may seem void of project courses, though some of the electives available typically include project-work counting for something like 40% of the grade. Several of the project courses shown in the figure have been analyzed in previous research. The project in the 7th semester has a long tradition, as 20 years of experience was reported already in (Andersen, Conradi, Krogstie, Sindre, & Sølvberg, 1994). The 4th semester project has been discussed in (Dingsøyr, 2022; Kolås & Munkvold, 2017; Sindre, Stalhane, Brataas, & Conradi, 2003), and the 8th semester interdisciplinary project for instance in (Jaccheri & Sindre, 2007). Project courses in the department outside the study program shown in Table 1 have also been the topic of research. For instance, Hjelsvold and Mishra (2019) report on experiences from project courses in global software engineering and open-source software engineering in the Master of Applied Computer Science in the Gjøvik campus. Rouhani et al. (2021) discuss the usage of project-based learning in a programming course for in-service teachers. (Krogstie, 2010) discusses the usage of collaboration tools, in particular in a project course in the bachelor Informatics program. However, these papers have not focused specifically on feedback in the project courses, except for (Dingsøyr, 2022) whose study evaluated an intervention for improved feedback during the 4th semester software engineering project. Key recommendations were the importance of training the teaching assistants involved in feedback, and of timeliness and fairness. With 500 students taking that project course, (Dingsøyr, 2022) also contained advice on how to deal with such scale.

Feedback in project-based learning has also been a topic of international research. For instance, Palmer and Hall (2011) find that students considered the feedback during the project very helpful in making progress. Frank and Barzilai (2004) present an approach based on eight guidelines for continuous formative feedback in a project course, finding that students found the approach useful in several different ways. Cook et al. (2019) in particular discuss student peer feedback during projects, finding that the quality of peer feedback can vary a lot, but can be boosted by training and by the teaching staff providing guiding questions that the students could consider during the peer feedback.

RESEARCH METHOD

It was chosen to exclude some project-like courses from the research reported in this paper. Courses where a project only was a minor part (less than 2.5 ECTS credits) were not considered. Moreover, we excluded research thesis courses. In Table 1, specifically, the Master thesis and Master thesis pre-project were deemed outside our scope of interest for two reasons: (i) in these courses, students are distributed among all professors in the department, receiving individual supervision. Hence, there is no unified approach to feedback in these courses. (ii) Many of these projects are more research-oriented than engineering-oriented, and this paper focuses on engineering-oriented projects. Hence, while a study of feedback practices in thesis supervision is clearly interesting, it would be complicated to investigate that together with feedback practices in earlier, more design-oriented projects. Similar research thesis courses in other study programs were considered outside this paper's scope for the same reasons.

Hence limiting the scope to design-oriented project courses with projects of a certain size, invitation to interviews were sent out by individual emails to 18 teachers of such courses. Of these, 12 responded positively, and were interviewed individually in the period 9-16 January. All respondents gave informed consent that the interview data could be used in the research for this paper. Each interview was performed in a semi-structured manner, with main questions directly resembling the research questions given in the Introduction, and then follow-up questions based on the initial answers. The duration was 30-60 minutes, depending on the amount of information the teacher provided. Some teachers were also involved in several relevant courses. The data material was further analyzed through a thematic analysis. This is a method for analyzing qualitative data that entails searching across a dataset to identify, analyze and report repeated patterns (Braun & Clarke, 2006).

RESULTS

Findings on RQ1: Learning outcomes pursued in project courses

Generally, the learning outcomes in the project courses have the well-known division, knowledge, skills and general competence. The majority are aimed at development and understanding, with a mix of professional knowledge and skills. For example, the students should gain practical experience in carrying out an engineering project, develop their ability to organise and carry out such projects, and be able to apply theoretical concepts and design principles in practice.

Half of the project courses in this study also involve learning outcomes aimed at more generic skills, such as communication and collaboration. Several teachers emphasized the importance of students being able to communicate subject material orally, explaining what they have done in a project and why. One of the teachers explains the importance of this as follows:

> *Unfortunately, there are many engineers today who have some trouble explaining themselves professionally. They simply cannot communicate what they have done. This is important.*

Stated learning outcomes related to collaboration vary from general descriptions, such as, for instance, that the students should have insight into project work and development processes, to slightly more detailed descriptions. In courses where teamwork is at the center, students shall be able to explain how they establish and carry out teamwork, related to different models for teamwork and team development, and they must be able to carry out and document teamwork and reflect on their own professional practice. One of the teachers elaborates:

> *We spend some time getting them (the students) to understand that teamwork is something else than traditional group work. In a group work, they sit together and distribute tasks: "You do task 1, you do task 2, and then I do task 3, and then the three of us get to do all the tasks with only a third of the work each." This is not teamwork. Teamwork is when we make use of each other's*

good and bad qualities together to bring about an interaction that gives added value, which means that we achieve something together, which we could not have achieved individually. So, the sum is greater than the sum of each individual.

Although not all the project courses involved in this study have collaboration as one of their 'official' learning outcomes as such, the value of collaboration is emphasized by most of the teachers, described as a more implicit benefit of the course. Quotes from two teachers:

Being able to do practical work in groups is very useful. Although we focus on the professional, of course. We don't have the capacity to take care of group processes etc.

Teamwork is important. But I don't think we have this as a learning outcome. Becomes a more implicit gain.

Findings on RQ2: Approaches to assessment and feedback

Most of the courses involved in this study are pure project-based courses, where the end-of-course exam has been replaced by a form of portfolio assessment, with typical parts such as report, reflection, demos, presentations, video, and product. Many of the teachers in this study indicated a purpose to create an arena for continuous student effort that provides a good basis for learning. One of the teachers describes his motivation for project-based courses as follows:

When I took over the course, it was exam-based. A very classic format for a university subject. Where the exercises were more of a ticket to sit the exam. The effort on these was below par. And this was very much reflected in how the students did on the exam. Because they weren't quite able to ... well, they had trouble with deeper reflection questions. Especially in relation to what theory means in practice. You have the theory, you apply it, but you also must reflect on it. This gives you a different view of the theory. And this is what a project course can add, the reflection loop. Now I only use group reports, not school exams. These provide completely different opportunities for students to reflect.

For most courses studied, the final report is the key submission in the portfolio. However, what this entails varies greatly between courses. For some it consists of several changed, and hopefully improved, versions of exercises, while others are made up of several projects or sub-projects. Some may include a preliminary study where the students plan their own project or survey the subject area. Others focus more on demos and presentations. For other courses again, user testing is central. Some courses also include retrospective parts, where students reflect on their own work process and possible improvements to the next part of the project. The latter is an important part of the well-known agile method Scrum that several of the teachers have implemented in their courses, a method well known also in software engineering education elsewhere (Kulmala, Luimula, & Roslöf, 2014; Paul & Behjat, 2019).

The number of exercises, projects and sub-projects included in the final reports also varies between different courses, as well as the weight of various parts in terms of scores or grades. The final reports often contain the students' academic arguments for choices made during the project, an analysis of the entire project work, or reflecting academically by linking their project to relevant theory. Several of the final reports also involve, albeit to varying degrees, a reflection note where the students reflect in teams or individually, or both, on the team's work process and the students' collaboration skills and how these have developed in the project. Most of the courses have a final grade, and the students are often assessed as a group. A small number of the courses have pass/fail on the final assessment, but several of these, however, plan to change back to letter grades. This to make it easier to bring out the nuanced differences between the students, and to reward students making a good effort over those who do not. However, others strongly argue for the use of pass/fail in project courses. The core argument is that this gives the groups a common goal, while at the same time the rush to achieve, which they believe students often experience with grades, decreases considerably. However, the requirement for passing must be at a high level. Quotation:

> *We have passed/failed. It is a proven choice. Not because this makes it easy to assess, but we want to avoid competition both internally within the group and between the groups. If it becomes talk of "I'm going to get an A, but he only deserves a C", then that doesn't make for good teamwork. Teamwork works well when the team has a common goal, which is in many ways the definition of a team. Our experience is that cooperation between students is best with the use of pass/fail, and when the requirement for a pass is relatively high.*

Common to the different variants of assessment described above is that the students receive guidance and regular feedback on their own work throughout the semester. In the smaller courses, the teachers themselves are actively involved in the guidance process and give the students feedback, while in the slightly larger courses this responsibility is given to learning assistants who are associated with the course. A central challenge here, according to several of the teachers, is the quality of the feedback from the assistants. Several of the teachers therefore spend a lot of time and resources on training and follow-up of the assistants, in order to raise the professional level of the feedback work.

Some courses have also included peer assessment as an important part of the assessment practice, where the students are actively involved in assessing their fellow students' work, which further increases the overall amount of feedback received and produced. One of the teachers describes his motivation for using peer assessment in this way:

> *The practice of making things from scratch is often quite far from the reality the students will face after their studies. It is often expected that they should be able to familiarize themselves with other people's projects and have an opinion about it. Not least understanding other people's codes. This is a professional competence. They need this judgment.*

Findings on RQ3: Prioritization of assessment and feedback vs. outcomes

For most courses involved in this study, the academic learning outcomes weigh the most in relation to what is assessed, both during the courses and in the final reports. Although several courses involve reflection on more generic skills such as collaboration, most of the final reports have a stronger focus on technical engineering competence. Quote from one of the teachers:

> *I would perhaps say that it is not in the reflection around the group process that the grades mainly lie. It probably isn't. Quite the contrary.*

The exceptions are the courses where the students' teamwork is central, where the guidance and feedback along the way are linked to the team itself and their collaborative process, but here, too, there is a wide spectrum from the courses that have teamwork as one of their core areas, to those that include a reflection note at the end, but leave it more up to the students to assess what should be included. Three lecturers, from three different courses, say the following:

> *No, it's no big deal, no. They can say a little about the group dynamics if they want to.*

We do not have a separate process report, like experts in teams, but the development process is part of the subject, so teamwork will be a natural topic for them to discuss in a reflection report, even if the reflection is overall mostly professional.

I think it is difficult to be absolutely sure how well the students reflect on their own collaboration skills. But they write these documents, they have written an agreement between themselves for cooperation, they evaluate their own efforts against this repeatedly, and they have to discuss this in the final report and evaluate their own efforts, so at least we see that they have reflected on this and made an effort to assess their own skills.

DISCUSSION

Interpretation of Findings

For RQ1 about learning outcomes, most of the project courses investigated were seen to have a mixture of technical, disciplinary learning outcomes and more generic learning outcomes such as interdisciplinary skills. All project courses had clearly stated disciplinary learning outcomes, while the presence of explicit interpersonal learning outcomes varied among courses. The most explicit attention to generic, interpersonal learning outcomes was found in the fully project-based courses. This is not surprising, as some of these courses have been designed as project-courses from the outset, because teachers and educational leaders have seen a need to address such outcomes in the study plan. The courses where projects only constitute a smaller part have typically started out as more old-fashioned lecture plus exercise courses with a solely disciplinary technical and theoretical focus but have gradually moved towards projects for instance to address motivational issues. Hence, considering the four types of learning outcomes that Guo et al. (2020) mention for projects, all courses could be seen to focus on cognitive outcomes (e.g., disciplinary knowledge) and artefact outcomes (e.g., quality of the designed artefact), whereas focus on behavioral and affective learning outcomes was most explicit in the courses that were fully project-based, and even here to a varying degree.

For RQ2 about approaches to assessment and feedback, the finding was that feedback on project work during the semester is provided mainly by teachers themselves in smaller classes, to a larger extent by teaching assistants in larger classes. This is understandable, as the class size differs a lot. For a class with 30 students, divided into 5-6 project teams, it may be possible for the teacher to provide detailed guidance to each team. For a class with several hundred students, this would not scale, so one would have to rely on teaching assistants and/or student peer feedback. Only two of the investigated courses had explicit setups for peer assessment and feedback, though in many of the other project courses there would be some implicit feedback between peers inside each project team. While no teachers used the exact 8 guidelines for formative feedback as proposed by Frank and Barzilai (2004) or Cook et al. (2019), many similar ideas were found concerning the importance of preparing students for teamwork up front and training students and teaching assistants on how to work with feedback.

Concerning RQ3 on the extent to which various learning outcome are assessed, the findings of this study is aligned with previous research, observing that outcomes related to disciplinary knowledge and the artefact are assessed to a much larger extent than for instance improvement in collaboration skills. As observed by Guo et al. (2020) and Scoular (2021), collaboration skills are hard to assess, so it is not surprising that this is done to a latter extent. No teachers claimed to really assess whether the students improved in this respect, although at least in some courses the students had to reflect upon their collaboration and communication.

Limitations and threats to credibility

There are several limitations to this study. One is that it investigates project courses just in one department (Computer Science) in one university (NTNU). Similar investigations elsewhere might arrive at different results concerning learning outcomes and assessment approaches. However, the department is quite large and broad, recently merged from several different smaller department with different educational cultures and geographic locations. Hence, despite being limited to just one department, there are several different academic and engineering traditions represented by the teachers and project courses studied.

Another limitation is that the study only interviewed teachers, not students. This was a deliberate choice implied by the research questions, investigating the intended learning outcomes of the courses and the learning and teaching approaches designed by the staff to achieve these outcomes – not to find out about student satisfaction or their actual learning from the courses. A follow-up study also looking at the courses from the student angle would be interesting but was considered beyond the scope of the current study. An obvious threat to validity is that teachers might consciously or unconsciously portray their courses in a more positive light than what is really mandated. Not having talked to students, this study cannot guarantee against such a weakness, but the impression was that teachers tried to be frank about their impressions about course outcomes and assessment approaches and were open in mentioning challenges they were facing with the course design and operation.

Conclusion

In line with other literature, the project courses studied here seemed to play an important role in their respective study programs, exposing students to realistic and motivating problem-solving tasks where they can link theory and practice. However, as also reported in other research, assessment of cognitive outcomes and technical design skills seem to be more mature than assessment of interpersonal skills like communication and collaboration, where the assessment approach is still very rudimentary. Hence, more educational research and innovation is needed on how to assess interpersonal skills such as collaboration and whether students improve during project courses. Still, teachers need not wait for this future research to do something. If a project course currently has no assessment of communication and collaboration skills, inclusion of some evaluation through student perception (e.g., questionnaire on whether they think their skills improved through the course, or reflection notes about how their skills developed), would be much better than nothing. Based on these perceptions – and preferably in dialogue with students – one could then consider whether it is possible to move on to assessing actual skill improvement from observed performance.

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BIOGRAPHICAL INFORMATION

Gabrielle Hansen is a senior researcher at the Excited Centre of Excellent IT Education. She holds an MSc in Psychology and a PhD degree in Pedagogy with a thesis focusing on the use of feedback in higher education. Before joining the Excited centre, she has been a researcher at the Sør-Trøndelag University College (HiST) and then at the SEED Centre for Science and Engineering Education at the NTNU, in both cases working on educational improvement interventions and the coaching of teachers during such processes. In addition to research on feedback and assessment, she has also done research on the usage of Student Response Systems in lectures.

Guttorm Sindre holds MSc and PhD degrees in Computer Science (1987, 1990). He has been a full professor at NTNU since 2003, where he served partly as Head of Dept, partly as deputy head of the CS department 2009-13. He was the leader of the Excited Centre for Excellent IT Education from 2016-21, is currently deputy leader of Excited, and study program board leader of Informatics. Sindre has teaching experience across a wide range of IT topics, from freshman introductory programming to PhD level research courses, as well as supervising several master and PhD students. His research has focused on computing education, especially how to teach introductory programming, how to mitigate threats to assessment integrity, and (before the Excited centre) on software requirements engineering and software security.

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