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Teachers' Reflections On Their Experiences Teaching Interdisciplinary Project-Based Courses

Malin KJELLBERG
Engineering Education Research, Department of Communication and Learning in Science, Chalmers university of technology, Sweden, malin.kjellberg@chalmers.se

Michael O'CONNELL
Engineering Education Research, Department of Communication and Learning in Science, Chalmers university of technology, Sweden, oconnell@chalmers.se

Becky BERGMAN
Language and Communication, Department of Communication and Learning in Science,Chalmers university of technology, Sweden, rebecca.bergman@chalmers.se

See next page for additional authors

TEACHERS' REFLECTIONS ON THEIR EXPERIENCES TEACHING INTERDISCIPLINARY PROJECT-BASED COURSES

M Kjellberg[1]
Chalmers University of Technology
Gothenburg, Sweden
https://orcid.org/0000-0002-3272-878X

M O'Connell
Chalmers University of Technology
Gothenburg, Sweden
https://orcid.org/0000-0001-9695-0315

B Bergman
Chalmers University of Technology
Gothenburg, Sweden
https://orcid.org/0000-0003-3127-4816

C Stöhr
Chalmers University of Technology
Gothenburg, Sweden
https://orcid.org/0000-0002-0001-5873

J Larsson
Chalmers University of Technology
Gothenburg, Sweden
https://orcid.org/0000-0002-6265-0004

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ABSTRACT

In project-based, interdisciplinary engineering courses, teachers face the challenge of not only imparting technical knowledge but also facilitating effective project- and teamwork. In this study we conducted a thematic qualitative analysis of 11 teachers' reflections on interdisciplinary project-based learning (PjBL). The results show that teachers appreciated PjBL as a means to motivate students and that one challenge was handling differences in terms of student disciplinary background. While most teachers did not see a need for further training, teachers who did identify such needs also seemed to already apply a wider range of PjBL teaching strategies. We discuss the implication of our findings for both practitioners and researchers.

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[1] *Corresponding Author*
M Kjellberg
malin.kjellberg@chalmers.se

1 INTRODUCTION

Over the last two decades, engineering education has increasingly been applying more active, student-centered, and collaborative learning methods. Project-based learning (PjBL) is one approach often chosen because it resembles the engineering profession and confronts students with real-world problems that must be addressed in teams, often across disciplines (Kokotsaki 2016, Mills and Treagust 2001). Furthermore, PjBL offers opportunities for graduates to develop 21st century skills, professional and transferrable skills, like creative thinking, communication, problem solving, and understanding of the social context of engineering. (Andrade 2016).

Previous research has shown that despite several reforms in engineering education, CDIO, PBL, PjBL (Crawley et al. 2007, Mills and Treagust 2001), these have not yet resulted in a systemic change (Mitchell, 2019). One reason could be that teachers experience challenges preventing them from engaging in PjBL despite the benefits for student learning (Kokotsaki et al. 2016). Some of these challenges include embracing a new role as a teacher (Hmelo-Silver et.al., 2007), designing project-based teaching, fear of not covering enough technical or disciplinary content (Hung 2011), and tension between theory and practice (Crawley et al. 2007).

Additional challenges appear when courses are interdisciplinary, engaging student teams across study programs (Kjellberg et al. 2015). These challenges include the university organisation and the teacher role, not only as course examiner but also as project manager, team facilitator, and student mentor. Previous research has suggested that in an interdisciplinary course context, the teacher team need to cover not only the disciplines involved, but also specific interdisciplinary teacher competence (Van den Beemt et al. 2020). Other required teaching skills are communication, leadership, project management and group dynamics (Kokotsaki et al. 2016). Hence, interdisciplinary PjBL requires teachers, who come from traditional engineering disciplines, to teach in a way that they in many cases have not experienced themselves. While there are many studies that highlight the multiple benefits of PjBL in engineering education (Andrade 2016, Hmelo-Silver et al. 2007, Kokotsaki et al. 2016, Mills & Treagust 2003), there is a dearth of studies on how teachers address, and cope with these challenges and reflect upon their experiences (Mitchell 2019).

This study aims to explore teachers' experiences of and reflections on teaching collaborative interdisciplinary project courses with diverse project groups in a context where teachers might have little experience and education with PjBL but where the university has adopted a major change within its education. Tracks, a ten-year initiative started in 2019, aims to encourage teachers to design and offer interdisciplinary, collaborative, project-based courses, closely connected to current research, industry, or the wider community. The 3, 7.5 or 15 credits courses are based on proposals submitted by self-formed teacher teams of varying sizes across disciplines. All courses are electives and available to bachelor and master students as well as to professionals. The courses aim to be interdisciplinary in terms of the projects' topic and scope, and student and teacher backgrounds, although mostly

within STEM and particularly engineering disciplines. Currently there has been more than 500 students active within Tracks, taking part in one or more of the so far 25 offered courses. Student numbers within a course vary between 5-40 and they work in teams of 2-6 where the methods for forming teams vary between courses and are decided by theTracks course teacher.

Research questions: How do teachers support students in content learning and collaborative project work? When teachers evaluate the outcome of project-based courses, what aspects do they pay attention to? What training or support do teachers perceive they need?

In this text, we will consistently use the term "interdisciplinary," even though the teachers in this study employed a range of practices, including cross- and multidisciplinary approaches (Meeth 1978).

2 METHODOLOGY

A two-part questionnaire was distributed to 27 teachers teaching different PjBL courses within the Tracks initiative. The first part of the questionnaire addressed background and motivation to engage in PjBL, and the second asked reflective questions concerning how teachers scaffolded students' content and collaborative learning; what worked well in their courses; what challenges they met; what changes they wanted to implement; and finally, what support they need to continue teaching project-based courses. We received 11 responses, on which we conducted a thematic qualitative analysis (Braun & Clarke, 2006). First, the responses to each prompt were coded inductively by the first author, paying attention to teachers' individual experiences. This resulted in a large number of codes that were discussed and revised together with the second author. Second, the whole material was coded looking for common themes in teacher responses across the prompts resulting in three overarching themes.

The responding teachers were diverse in form of gender and nationality, two females and five non-Swedish. Their previous experiences within project-based teaching and learning were primarily based on BSc and MSc theses supervision and small project courses and most lacked experiences of interdisciplinary teaching. Two teachers mentioned more than 10 years' experience of PjB teaching, although most of the respondents were not that experienced. All respondents have fulfilled the university's requirements of 15 credits of training in teaching and learning in higher education, including a mandatory course in diversity and inclusion, but no obligatory course in PjBL.

3 RESULTS

The results from the first part of the questionnaire shows that teachers were motivated to engage in project-based learning because it is fun, inspiring, and motivating for both students and teachers: *"(...) an interesting way to teach"*. Furthermore, teachers were motivated by the opportunities to let students work with open-ended problems, link innovative research to education, and explore topics

outside of core curricula. Two teachers valued the opportunity to start a new course in the shorter time that Tracks can offer, compared to what is needed within an established program.

Through the analysis of the responses to the second, reflective part, we saw the following overarching themes emerge: (1) where teachers invested their effort in supporting learning before, during and after the project course; (2) what they paid attention to when reflecting on their teaching; and (3) what changes they wanted to implement, including their need of (further) training and/or support.

3.1 Where are teachers investing their effort in supporting learning?

Teachers' strategies for investing their effort in project-based teaching were distributed on a spectrum between two course designs. The first one was to divide the course into two parts, where the first part was aimed at knowledge acquisition via lectures, seminars, or workshops. The second part consisted of industry or research related project work, where students were expected to apply the knowledge from the first part. Seven teachers used this approach, and it was predominantly chosen by teachers teaching courses that introduce students to a specialized knowledge area.

In the second course design, the course consisted only of project work and students were expected to acquire the knowledge needed to address the project task themselves, guided by teachers. This course design was predominantly chosen by teachers with more broad, general, and interdisciplinary project courses, where students chose their own projects based on a general theme rather than within a specialized area.

Across all course design types, there were several teacher approaches to support students' collaborative learning in their project- and teamwork. One aspect of this was how teachers to a varying degree controlled how students formed project groups. At one end of the spectrum, four teachers let students form groups entirely by themselves. At the other end, two teachers created as diverse groups as possible based on a set of criteria: disciplinary background, gender, interest, and scheduling. Finally, four teachers shared the responsibility of forming groups with students by letting them choose projects based on interest and adjusting the groups from there.

Ten teachers stated that they did not use specific models for the students to learn how to manage the project, process and define their roles in the team. Two teachers mentioned implementing course activities about project management, group dynamics, diversity and inclusion, and how to work in an interdisciplinary team. Two other teachers worked with reflective individual assignments. One of these teachers described this as: *"...a short reflection on the project progress and one's role in it. We hope that this will contribute to the project management-related learning objectives."* However, none of the teachers expressed that they had specific requirements for students to define and plan their project. Neither did they follow-up in any other way than via supervisor meetings and one expressed instead "*...students have to figure it out by themselves".*

Interestingly, among the seven teachers implementing a divided course design including lectures, seminars, and workshops, only two mentioned facilitation in project management or group dynamics. However, most teachers mentioned varying degrees of supervision to facilitate the project work. One teacher reported: *"Project management and teamwork was mainly facilitated by the main supervisor keeping track of the project and making sure that all students participated and found a good role in the project team".* However, only one teacher reflected on how the supervision worked: "*What I have experienced very critical for a good result is how to manage a balanced supervision where the supervisor is neither too detailed nor too vague in the instructions."*

3.2 What do teachers pay attention to when reflecting on their project-based teaching?

When considering teacher reflections on what they experienced went well, challenges they met and future changes they would like to implement, three subthemes emerged: project outcomes, diverse student groups, and students' knowledge backgrounds.

In the subtheme **achieved project outcomes,** four teachers explicitly mentioned that their student teams finalized their project, delivered satisfactory results, and produced well-written reports and presentations. None of the 11 teachers expressed any student team failing their project. Three teachers related the achieved outcomes to their course design; that introduction lectures and other activities successfully supported learning, and the application of knowledge in a project. One teacher related the success of their course to the opportunity of offering a variety of project topics based on real-world problems. Another one stated: *"My overall impression with teaching the project-based teaching Tracks course is positive, all students have applied specifically to this course and are motivated. The projects I use have been designed to allow students to use their respective backgrounds to go deeper into specific areas of the course. In my course the projects compliment the more general lectures and material in course in a good way."* Furthermore, one teacher mentioned "... *at least one of the projects led to real-world implementation in industry and employment for one of the students."*

In the subtheme of **diverse student groups,** teachers evaluated the outcome in terms of the student body taking the course. Two teachers expressed that they were happy with the mix of students, and one of them stated: "... *with good projects and good supervisors this diversity can strongly benefit the projects and the learning outcomes."* At the same time, another teacher mentioned being impacted by cultural differences, for example in different student groups' ways of asking questions. While one teacher shared that their students formed diverse groups without any intervention from the teacher team, another mentioned challenges in recruiting a diverse interdisciplinary student group since the Tracks courses are not well known in the educational program organisation. With few students and some dropouts, group projects were difficult to achieve, even more so diverse groups. Finally, two

teachers saw less, or no, effects or issues related to diversity aspects like gender, age, or nationality.

In the subtheme **students' knowledge background,** seven teachers expressed that their greatest challenge has been the diversity in student knowledge level and background. Two of the seven teachers shared that they consciously tailored the lectures and other learning activities to the diverse disciplinary and broad educational background of the students. Another started with a quiz to identify differences and designed specific learning activities for those not having the prerequisites needed for the project. One teacher reported adjusting project scope, goals, deliverables, and boundaries to the students' background and interest. Interestingly, one teacher reflected: *"Some students were unhappy that the background knowledge of their teammates was much less than their own. Next year we'll maybe create more homogeneous groups."*

3.3 Future changes and perceived needs of support and training

When asked about what they want to change in their future teaching, five teachers planned to adjust their courses, although project outcomes were successfully met. One teacher wanted to increase facilitation of teamwork using a student group contract in the project start discussing roles and responsibilities, teamwork climate, decision-making and conflict resolution. Furthermore, the same teacher wanted to implement continuous peer assessment to support the students during project work. Another teacher mentioned adjusting course length, based on student feedback, to concentrate the project work during shorter time, and use the available makerspace, *"(...) to get better collaboration and learning cross groups (...)".* One teacher wanted to include more hands-on activities and study visits, and yet another an exchange with student groups within the same topic in a different context at another institution.

Of the eleven responses, only two teachers expressed specific needs of further training in project-based teaching and learning. One teacher wanted to improve their leadership skills to manage student project process better, and the other requested a "*pedagogical course joining outcomes from project-based teaching in different disciplines",* since project-based teaching differed between disciplines.

Four teachers mentioned that they have sufficient knowledge already, and one of them shared that it was being part of a well-connected teacher team that inspired and developed their teaching skills. Three teachers mentioned missing the collegial discussions they had in the required teaching and learning courses and wanted to see opportunities for these to continue. One teacher shared that in their department, they have several collegial discussions on project-based learning since their research and education is often connected to industrial development performed in team-based projects. Another teacher mentioned: *"I don't feel I need training, but best practice examples from other courses are always welcome."*

4 DISCUSSION

We set out to study teachers' experiences with teaching interdisciplinary project-based courses with diverse student groups. Our research questions were: How do teachers support students in content learning and collaborative project work? When teachers evaluate the outcome of project-based courses, what aspects do they pay attention to? What training or support do teachers perceive they need?

We got 11 teacher responses from the questionnaire; hence this qualitative study does not aim to get generalizable results. Rather, the open question design aims to saturate the range of perspectives among teachers. Still, we do believe that our results are transferable to universities in similar contexts with a limited experience of systematic interdisciplinary project-based teaching.

In general, teachers recognized and motivated their project-based teaching with key benefits that coincide with the project-based learning literature. These benefits include enhanced student motivation, better application of interdisciplinary theoretical and practical knowledge through authentic work- and research-related problems, and the development of essential generic and transferable skills (Shin 2018, Kokotsaki 2005).

Related to support of students' content learning, teachers chose course designs with varying degrees of openness with some focusing entirely on project work, but most adding more traditional lecture- and/or seminar-based activities, coinciding with findings by (Hung 2011). Interestingly, we were able to identify a link between the course content and the learning design, where more specialized research-based or industry-connected courses tended to utilize traditional methods to a higher degree compared to more broad and general courses. It appears that in these courses, teachers used lectures and seminars as a strategy to level the knowledge base among students before or during the project implementation. One interpretation is that these courses have knowledge specific learning objectives, like introducing a particular technology, and thus less effort can be put into training of generic and transferable skills to conduct interdisciplinary, collaborative projects. Courses also varied in their degree of student self-directed learning. While PjBL models typically stress a high degree of student autonomy (Hung 2011), this leads to the discussion of the role of enhanced self-regulated learning skills, which is an outcome of PjBL as a teaching approach. But these skills are also a pre-condition for students to effectively engage in PjBL, and that needs to be supported by the teacher and the learning design (English & Kitsantas 2013, Van der Beemt et al. 2020).

While teachers typically put a lot of effort into content learning in their course design, it appears that they paid less attention to questions of whether and how to scaffold collaboration during the project work. No explicit support was given for the definition and planning phase of the project, except for regular supervisor meetings in some cases, or how to monitor and evaluate their learning as a group. Furthermore, very few teachers report that they use models for project and team facilitation. Rather, an unstructured approach where students "need to figure it out themselves" appears to be the standard. While these kinds of "desirable challenges" (O'Connell et al. 2021)

can foster student learning and problem-solving capabilities, we argue that a full hands-off approach can be problematic, particularly in interdisciplinary, diverse groups. This concern is partly supported by our results; although teachers homogeneously assessed their course results as very positive, their evaluations primarily pay attention to project outcomes, not the collaborative learning outcomes. Thus, it is left to chance that the group composition, individual management and regulation skills of its members result in high quality learning.

While researchers and the teachers in this study see group diversity in general as beneficial to student learning (Bergman et al. 2023), many teachers found it challenging to create learning benefits in project teams of students from different disciplinary backgrounds. If not adequately supported, there is a risk that avoidance strategies by both teachers, e.g., through forming homogenous groups, and students, e.g., by splitting tasks, to maximize independent work without joint monitoring, compromise the expected learning benefits of interdisciplinary PjBL (O' Connell et al. in review). Thus, instead of leaving collaboration to chance and assuming that the expected benefits of collaborative learning will emerge, we suggest that interdisciplinary diverse student groups in particular benefit from scaffolding, explicitly addressing aspects of group dynamics, project management and social regulation of learning. Research shows that students need help in forming diverse groups, both in terms of cultural and disciplinary background but that such groups are likely to be more creative, dynamic, and productive (Rientes et al. 2014). However, the success of diverse groups is more dependent on scaffolding, especially during the project start up (Bergman et al. 2017).

We noted that teachers, when asked about what training they need, focus on collegial discussions. Very few teachers see a need for formal training in how to support student collaborative learning or teamwork. This might be due to teachers not being aware of the resources and research that exist on how to support PjBL. Interestingly, those who reported a need for further training, also used a wider range of scaffolding strategies in their project-based course design.

In conclusion, the overall positive teaching experiences reported here can serve as encouragement for other teachers to engage in interdisciplinary PjBL. As shown, a variety of learning designs can thereby be effectively used to engage students in PjBL. Based on our results though, we call for more attention to the group aspects of PjBL. It could be argued that teachers just need further training or education, but as our result show this is not easy when teachers themselves do not see the need. Hence, we need further research into best practices and interventions to scaffold collaborative learning, to support teachers in developing the necessary awareness and skills to facilitate students' project- and teamwork, particularly in interdisciplinary project courses with diverse student groups.

REFERENCES

Andrade, Maureen Snow. "Curricular Elements for Learner Success--21st Century Skills." *Journal of Education and Training Studies* 4, no. 8 (2016): 143-149. https://doi.org/10.11114/jets.v4i8.1743

Bergman, Becky, Raffaella Negretti, Helen Spencer-Oatey, and Christian Stöhr. "Integrating Home and International Students in HE: Academic and Social Effects of Pair Work PBL Assignments Online." *Journal of Studies in International Education* (2023). https://doi.org/10.1177/10283153221150117

Bergman, Becky, Anthony Norman, C. Carlsson, Daniel Nåfors, and Anders Skoogh. "Forming effective culturally diverse work teams in project courses." In *13th international CDIO conference proceedings CDIO*, pp. 18-22. 2017.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Crawley, Edward, Johan Malmqvist, Soren Ostlund, Doris Brodeur, and Kristina Edstrom. "Rethinking engineering education." *The CDIO approach* 302, no. 2 (2007): 60-62.

English, Mary C., and Anastasia Kitsantas. "Supporting student self-regulated learning in problem-and project-based learning." *Interdisciplinary journal of problem-based learning* 7, no. 2 (2013): 6. https://doi.org/10.7771/1541-5015.1339

Hmelo-Silver, Cindy E., Ravit Golan Duncan, and Clark A. Chinn. "Scaffolding and achievement in problem-based and inquiry learning: a response to Kirschner, Sweller, and." *Educational psychologist* 42, no. 2 (2007): 99-107. https://doi.org/10.1080/00461520701263368

Hung, Woei. "Theory to reality: A few issues in implementing problem-based learning." *Educational Technology Research and Development* 59 (2011): 529-552. https://doi.org/10.1007/s11423-011-9198-1

Kjellberg, K., T. Adawi, and K. Brolin. "Challenges in implementing PBL: Chalmers Formula Student as a case." In *Proceedings of the 43rd Annual SEFI Conference*. 2015.

Kokotsaki, Dimitra, Victoria Menzies, and Andy Wiggins. "Project-based learning: A review of the literature." *Improving schools* 19, no. 3 (2016): 267-277. https://doi.org/10.1177/1365480216659733

Meeth, L. Richard. "Interdisciplinary studies: A matter of definition." *Change: the magazine of higher learning* 10, no. 7 (1978): 10-10.

Mills, Julie E., and David F. Treagust. "Engineering education—Is problem-based or project-based learning the answer." *Australasian journal of engineering education* 3, no. 2 (2003): 2-16.

Mitchell, John E., and Lynne Rogers. "Staff perceptions of implementing project-based learning in engineering education." *European Journal of Engineering Education* 45, no. 3 (2020): 349-362. https://doi.org/10.1080/03043797.2019.1641471

O'Connell, Michael, Tom Adawi, Hana Trefna, Anna Ström, Christian Stöhr. "Challenge Episodes and Coping Strategies in Undergraduate Engineering Research". In *Proceedings of the 49th SEFI Conference: Blended Learning in Engineering Education: challenging, enlightening–and lasting?.* (2021)

O' Connell, Michael, Christian Stöhr, Patric Wallin. (in review). "Social Regulation of Learning in Interdisciplinary Groupwork". Submitted to: *European Journal of Engineering Education.*

Rienties, Bart, Peter Alcott, and Divya Jindal-Snape. "To let students self-select or not: That is the question for teachers of culturally diverse groups." *Journal of Studies in International Education* 18, no. 1 (2014): 64-83. https://doi.org/10.1177/1028315313513035

Shin, Myeong-Hee. "Effects of Project-Based Learning on Students' Motivation and Self-Efficacy." *English Teaching* 73, no. 1 (2018): 95-114.

Van den Beemt, Antoine, Miles MacLeod, Jan Van der Veen, Anne Van de Ven, Sophie Van Baalen, Renate Klaassen, and Mieke Boon. "Interdisciplinary engineering education: A review of vision, teaching, and support." *Journal of engineering education* 109, no. 3 (2020): 508-555. https://doi.org/10.1002/jee.20347