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Enhancing Professional Skills Among Engineering Students By Interdisciplinary International Collaboration

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ABSTRACT

Providing necessary knowledge and skills for engineering students to become successful professionals is a tricky task. Besides disciplinary knowledge, e.g., communication skills, ability to work in teams, and international experience are often mentioned as important. Regarding internationalization, most engineering programs in Sweden rely on either student exchange or low-level internationalization-at-home, such as international literature and lecturers. This paper explores sustainable international experiences for students on their home turf provided through an international interdisciplinary collaboration where engineering students in Sweden and marketing students in Australia work together on a project. The setup simulates a consultancy firm with development and marketing offices in different countries that

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cooperate to launch an application for the Australian market. The paper is based on interviews and surveys with students and teachers participating in this, since 2017, ongoing project.
Findings reveal that students encountered several challenges that are hard to simulate in an ordinary university setting, e.g., language barriers, cultural differences, time differences, differences between disciplines, and varying work habits and values. The results also highlight opportunities such as learning from each other's perspectives and expertise, developing a more professional approach, presenting to people from other industry backgrounds, and gaining a better understanding of different cultures. The results show that the students gain professional experience that is of great value for their future profession. From a teacher's perspective, the paper discusses important issues when setting up an international inter-disciplinary collaboration, e.g., alignment of exercises, building a common ground, and the need for flexibility.

1 INTRODUCTION AND BACKGROUND

The advancement of technology has significantly impacted society, with engineering at the forefront of this development. The application of science, mathematics, economics, and social science has led to innovative engineering solutions that create value and intersect with scientific discoveries, technological development, and societal changes (Kumar 2018). Consequently, working as a professional engineer is demanding and requires diverse skills and knowledge. Some of the more generic skills that have been sought after by the industry for a long time are the abilities to collaborate and communicate across disciplines in a real-world context (Ertas et al. 2003; Mechefske et al. 2005). These skills are not unique to engineers but something that is important for all students. Hence, it is important for higher education to create curricula that develop skills in a relevant real-world context (Cardozo et al. 2002).
According to Fox (2022), "there is a need to help engineers develop skills for engaging with and working in international collaborative teams, particularly those useful for establishing and managing relationships across cultures and disciplines". Consequently, an important real-world context is the international perspective both within but also between disciplines. Internationalization can be defined as "the process of integrating an international, intercultural, or global dimension into the purpose, functions or delivery of postsecondary education" (Knight 2003). Furthermore, globalization has accelerated the need for international experiences in engineering education to prepare students for diverse work environments (Borri, Guberti, and Melsa 2007; Guillotin 2018).
This practice paper explores the concept of providing sustainable international experiences for students on their home turf through participating in an international interdisciplinary collaboration. Specifically, the paper reports on a collaborative project between a marketing course at Edith Cowan University (ECU) in Perth, Australia, and an engineering course at Umeå University (UmU) in Umeå, Sweden. Furthermore, learnings from a teacher's perspective of setting up and refining such a project are discussed. The setup of this project is based on a couple of goals: (1) Students should gain international experience without leaving their home country, (2) students should work in a simulated professional setting that is close to a real-life situation, (3) students should experience true inter-disciplinary collaboration, and (4), students should learn how to communicate their knowledge and discuss their work with those outside their discipline. The first three goals were set up at the very start

of the project in 2017 while the fourth goal has been added due to the importance of communication in collaborative situations and the reality that students seldomly get the opportunity to communicate their knowledge to non-disciplinary persons.

2 METHOD

The results in this practice paper are based on learnings from the teachers' designing and facilitating the collaboration between students. Students' views have been collected using entry and exit surveys during the courses where the students could write their view on their expectations on the collaboration (entry) and thoughts on collaborating (exit). Furthermore, semi-structured group interviews discussing the students' thoughts about the collaboration and their suggestions for improvements were performed to collect data for improving the collaboration. Consequently, this project has been conducted in an iterative process to gradually refine and change the collaboration to reach the goals of the project incorporating student feedback and academic and industry input. This project has currently finished seven iterations until fall 2022. Data has been collected during all these iterations; student quotes in this paper were taken from exit surveys during collaborations between 2019–2022.

3 CONSTRUCTING A PROFESSIONAL ENVIRONMENT

Project-based learning has gained popularity in engineering education as it offers a setting that can enhance both generic skills and discipline-specific skills among students (Mills and Treagust 2003). According to a review by Kokotsaki, Menzies, and Wiggins (2016), guiding students, having high quality group work, and basing assessment on peer evaluation are regarded as recommendations for successful project-based learning.

The collaboration was structured as a partnership between a marketing team in Australia and a software/UX development team in Sweden, located in different offices of a hypothetical digital agency. The project's broad problem definition allowed students to shape the project and reflected real-world scenarios where all necessary information for a project may not be readily available, like what students may face in their professional careers after graduation.

3.1 Development process

Working according to pre-defined processes is common within most areas. Within engineering or any discipline with a focus on development, there is often a product/service development process that is followed. This is common practice within the industry. Establishing common ground is important to understand both the process and the team's or individual's role in the process. In the case of Swedish engineering students collaborating with marketing students from Australia, design thinking can help bridge the gap between their different backgrounds and expertise. In this case, the general design thinking process was proposed as a basis to structure the students' work and give them a common ground to understand all steps of the process, from idea to market pitch, of a working prototype. Design thinking is a problem-solving methodology that focuses on understanding users and their needs to create innovative solutions that are both functional and appealing. It is a creative iterative process that is focused on understanding the users and the context.

The common design thinking process involves the following stages – *empathize*, *define*, *ideate*, *prototype*, *test*, and *launch* (Fig. 1). During the empathize phase, the focus is on understanding the users and their needs. This was done through e.g., research, interviews, and observation. In this case, the ECU marketing team

conducted market research to understand the needs of potential customers and developed customer personas.

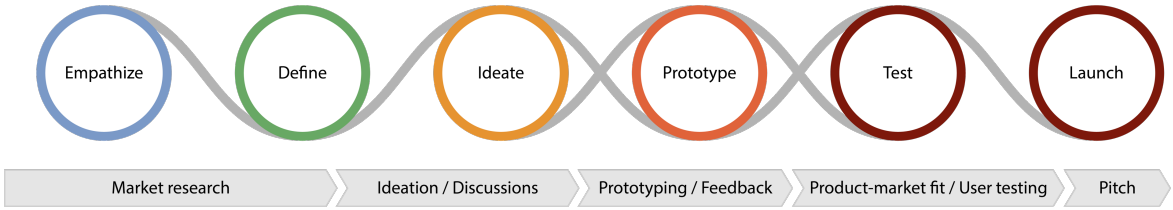

Fig. 1. A design thinking process was used to structure the work of the collaboration.

In the *define* phase, the problem is defined based on the insights gained from the empathize phase. This helps ensure that the problem which is addressed is the right one. The *ideate* phase involves brainstorming and generating a variety of functions and solutions. This is where the interdisciplinary collaboration shines because each group can contribute their unique perspective to the ideation process. The two teams identified problems and gaps in the market and discussed the practical feasibility of potential solutions. The ideation is executed through a teacher-facilitated session using a combination of applications for communication (Zoom) and collaborative whiteboard (Mural).

The *prototyping* phase involves creating a tangible representation of the solution and was divided into two milestones: a low-fidelity (LoFi) prototype and a high-fidelity (HiFi) prototype. These are sketches, wireframes, and digital prototypes, using e.g., Figma. The Swedish engineering students capitalize on their technical skills to create the prototype, while the marketing students provide feedback on product-market fit of the solution.

The *testing* phase involves evaluating the prototype with users to gather feedback and refine the solution. This stage is crucial to ensure that the solution meets the users' needs and is feasible to implement in practice. Depending on the amount of time at the students' disposal, this phase was more or less rigorously done. Part of this stage was done though product-market fit and involved presentations by the ECU students of their findings. Finally, and connected the *launch* phase of the development process, the marketing team created 90-second pitches for funding to take the product to market.

The design thinking phases were iterative and provided feedback to each other. The students were encouraged to stay in touch and share their progress. Consequently, using design thinking in collaborative interdisciplinary coursework is a powerful way to bring together different perspectives and expertise to create innovative solutions that address complex problems. By following the design thinking process, Swedish engineering students and Australian marketing students can work together in a professional setting to create solutions that are not only technologically feasible but also appeal to the target market.

3.2 Digital spaces for collaboration

Instead of using one of the common platforms for education, such as Canvas, Moodle, or Blackboard, the collaborative digital tools have been selected based on their ability to support the design process. The choice of digital tools in educational settings should, furthermore, support the pedagogical ideas of the setup. Hence, collaborative digital tools were introduced to increase interaction and collaboration between students both in real-time and asynchronously. Tools that are currently used during the collaboration are *Microsoft Teams*, *Zoom*, *Mural*, and *Padlet*.

Microsoft Teams has been used due to its extensive use in the industry. Teams was used for student team meetings and for keeping the team members updated on the progress by posting summaries of work, prototypes, and making comments. However, the asynchronous interaction through Teams proved to be ineffective as students often forgot to check notifications. Zoom was utilized for real-time collaboration when having full classes. However, it required setup by the teachers and was limited to scheduled weekly meetings. Mural was used for real-time collaboration during team meetings using pre-prepared templates and canvases, e.g., ideation, product-market fit, and elaborating on value propositions. Padlet was used to post summaries of work and sharing research report with other students. The students were generally positive about the use of these tools and believed they improved the collaborative learning experience. It is worth noting that the more widespread use of digital tools during in the emergency remote teaching situations during 2020 and 2021 has significantly increased the general knowledge among students of both disciplines regarding the use of digital tools.

4 LEARNINGS

It takes time and effort to set up a working structure of a collaborative project where both parties experience value from the collaboration and professional skills are developed. After running this project eight times and refining it iteratively, there are a couple of areas that have been identified as important to the process – *introduction*, *interactions*, *collaboration*, *digital tools*, and *timing*.

Introduction. Due to the large number of unknowns at the commencement of the collaboration, the introduction to the collaboration becomes very important. The students need to understand the holistic view and how they fit into the process. Even though one of the project's goals is to expose the students to the unknown, the misconceptions should be kept to a minimum. Hence, it is important that the students have a good understanding of the course's structure and the collaboration, so they can focus on the educational "unknowns". The continued improvement of the introduction process has created greater engagement and commitment from the students. In the pre-collaboration survey student express sentiments like these "I think I will get an experience in working with people that have other experiences and perspectives. I think that is a good way to prepare for the future since you will meet and work together with a lot of different people". Teachers are open about both strengths and opportunities for improvement with the setup and students are invited as co-creators of the collaboration. Furthermore, by working with a common development process, in this case the design thinking approach, it is easier to introduce the students to the project and make their roles and responsibilities clear. To further strengthen the understanding of the holistic project view, introductory lectures to the other students' discipline are important.

Interactions. Lecturer-facilitated and student-driven interactions are important to the process, and they have gradually increased over the years and the changes show that more teacher-driven interactions (e.g., scheduled joint class and team meetings) lead to more initiative on the students' side and more student-driven interactions take place (e.g., student scheduled real-time meetings). This is mainly due to more challenges surfacing with the increase in online discussions that in turn requires more meetings, online discussions, idea clarification and exchange. The students express this as: "We had to explain our process in an understandable way to students who are not as familiar with the area of our study. In the other way around,

we did get some insights regarding their field of study" and "Understanding our differences and our similarities".

Collaboration. Having a real collaboration that requires multiple touch points is important to create intrinsic motivation among students. A substantial portion of the courses are project work that two students need to perform in collaboration with each other ensures that all students actively participate in the international interdisciplinary experience. As one student expressed it: "Learning about different styles of communications, commitment to complete tasks". Even though the engagement among the students increased when the collaboration became more integrated, it is still recommended that parts of the courses that are critical for the students to get grades are kept either separate (by e.g., exercises of laboratory work) or that there is a backup plan if for example a delivery is not made on time, or the quality of a delivery is questionable. However, examination-critical parts should remain largely independent to minimize uncertainties for students and give them control of their possibilities to finish the course on time even in case of problems with the collaboration. The students express positive feelings towards being "able to try and collaborate with teams from another countries" and that they "are learning collaboration skills different from the one's you are used to (working with classmates)".

Digital tools. Since all collaborations are online, digital tools become important. The tools used have been chosen based on usability and accessibility and how they support problem-solving and collaboration. This means that the toolbox has not been put together based on what the two Universities offer but rather what was needed. Furthermore, having in-depth introduction and demonstration of the tools used is necessary due to different experiences and backgrounds. Having a carefully selected set of digital tools increased the authenticity of the situation since online collaborative tools are commonly utilized in the workplace to interact with colleagues, crowd-source ideas, and engage users (de Marcos et al. 2016). This also increased the level of authenticity of the learning experience, the students expressed this as: "Thank you for proving us with the tools and knowledge which is helping me presently in my real time business/work".

Timing. Working between academic systems creates problems such as having different starts of semester, study breaks, and examination periods. It is important to account for these problems beforehand. In this case the course in Australia starts in mid-February and runs to late May, while the Swedish course starts in mid-March and end early June. Hence, the timing of the final assignments is no problem, but the timing of the start is. The solution in this case was that the Swedish students participate in an introduction a month before their course starts. During the first month of the collaboration, the marketing students partake in marketing research to complete the empathize step in the design thinking process. Aligning exercises is challenging but important to create a collaboration that runs smoothly.

Even though many of the concepts discussed above can, and should, be planned, there is a strong need for flexibility from both parties. Having an agile approach to the collaboration with e.g., possibility to stretch deadlines and make slight changes to the schedule, decreases the effect of issues regarding communication and interaction among students as well as mistiming. This was done by regular updates using a WhatsApp group among the teachers to inform and make fast decisions behind the scenes.

5 MOTIVATED STUDENTS

Self-Determination Theory (SDT) (Deci and Ryan 1985) is a psychological theory that focuses on human motivation and personality development. According to SDT, human beings have three innate psychological needs that must be fulfilled for optimal growth and development – *autonomy*, *competence*, and *relatedness*. SDT suggests that when these basic needs are met, individuals are more likely to experience intrinsic motivation, meaning they engage in activities for their inherent enjoyment and personal satisfaction, rather than just for external rewards or pressure from others.

Gaining international experience in a simulated professional setting that is out of the ordinary for the students is of great value. It is, however, important to have motivated students since they are co-creators of the learning experience. The main success factors lie in the intrinsic motivation created during the collaboration based on autonomy, competence, and relatedness experienced by the students.

Autonomy refers to the need to be in control of one's own life and decisions and is achieved by giving the students control over their work in the project. The students are the "owners" of their projects, and they can decide on e.g., their own roles and have input in the project timeline. The teams' autonomy was often regarded as a frustration at the start of the collaboration since "Ideas kept flying" and "It was a bit awkward at times, since nobody took charge". However, comments such as "building friendship" and "diverse ideas" suggest that once this initial ice is broken, the autonomy helps the students to feel more invested in the projects and increases their motivation to work on them. Hence, the teachers' involvement is kept to a minimum once the collaboration has started and the interactions are working.

Competence refers to the need to feel capable and effective in one's actions and is achieved by providing a problem that is suitable for the students' current level of knowledge. This makes them feel that they have the necessary resources and training to perform their assigned tasks effectively. This also includes providing technical support for the engineering students to master their task. Feedback is provided both by teachers and by other students, mostly by peer feedforward, to make the students feel more confident in their abilities. The students express this as: "It was really good experience. I think it will help to boost our self to get better understanding of the subject" and "[The collaboration] showed what a workplace project can be like with different departments and working together to product the end result".

Relatedness refers to the need to feel connected to others and belonging in social groups and is supported by facilitating and encouraging communication and collaboration between the two groups. This is done through both video conferences and online discussions, allowing participants to connect and build relationships with each other. This strengthens the students' bonds both in-group and between groups and was expressed as: "It broaden my learning experience by collaborating with international students. It also exposed me to seeing product design and development takes shape" and "Nice to get another perspective on things, both cultural and because of different competences", and "overall was extremely helpful to develop our communication and teamwork skills".

By providing exercises, tasks, and an environment that promotes autonomy, competence, and relatedness, a higher level of intrinsic motivation among the participating students can be noted. This becomes evident both in the projects' results but, foremost, in how engaged the students are in the discussions and the project during the courses. It also strengthens the feeling for the students to get to

practice in a more realistic situation. This was expressed as: “Collaborating with international students in this unit gave me another opportunity to work with people from another country which in itself is eye-opening. In my experience collaboration is a skill that is valuable skill that is appreciated in the workplace”, “I think it has been a great experience to work with people with different study backgrounds. I think that it’s similar to what we will meet in the future in our work”, and “To be honest, I was a bit concerned at first given that it was two different area of study. However, as the collaboration started, I felt privileged to form part of this collaboration. Collaborating with students in Sweden has beneficial in many ways academically as well as what I will take with me to my future work-place”.
The frustrations experienced by students are in line with the goals of the learnings and show that the design of the collaboration is working. Students express this as frustrations regarding “communication and Technical issues”, “different views”, and “sometimes, we don’t understand them or their expertise, and vice versa”. Conversely one student considered “much of the benefits with working together was also sometimes the frustrations; that we have different knowledge and different will that we have to agree on or at least explain why something is better/more problematic. But the frustrations were also a good practice”.

6 CONCLUSIONS

To summarize, creating a real situation where students collaborate across disciplines, countries, and cultures enhances their learning and provides relevant professional skills for their future profession. Setting up a collaborative international and interdisciplinary project such as the one described in this paper is not easy and requires fine-tuning the details to create a valuable experience for the students and considerable commitment form the teaching staff. Fundamentally, in our experience, this includes communicating the project’s goal clearly to the students, inviting them as co-creators for the overall learning experience while still pushing them towards taking responsibility and project ownership, choosing the right digital tools, and following a meaningful design process for smooth project implementation. Moreover, teachers need to ensure that practical matters, such as issues regarding the timing of lecture periods, are addressed and deliverables aligned well between the courses. By incorporating exercises, assignments, and a supportive environment that fosters autonomy, competence, and connection, we can observe a significant increase in intrinsic motivation among the involved students. This is evident not only in the outcomes of their projects but, more importantly, in their active engagement during discussions throughout the courses. For the students the benefits are “practicing speaking English, working in your role (example as a developer or customer or marketers), take part of different knowledge and practicing on agreeing on different opinions and on enplaning why something is important/problematic based on your experience”.

6.1 Future work

Some of the improvements mentioned by students is concerning the balance when in time work is carried out between the two student cohorts. The main objective for future collaborations is to make both the engineering and marketing students to work more in parallel and create exercises where the marketing students can provide more of the information needed to align the developed application with the market needs. In the current collaboration the later changes on the prototype and the idea

do not get researched towards the market. This would further strengthen the collaboration.

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