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Are Engineering Teachers Ready To Leverage The Power Of Play To Teach Transversal Skills?

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ARE ENGINEERING TEACHERS READY TO LEVERAGE THE POWER OF PLAY TO TEACH TRANSVERSAL SKILLS?

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ABSTRACT

What conceptions do teachers hold about learning activities to develop students' transversal skills? This qualitative exploration at a research-intensive engineering school draws on interviews and focus groups to explore teachers' ideas about developing individual transversal skills. We frame our analysis with a model that distinguishes three phases for skill development: conceptual knowledge (knowing), procedural skills (doing) and meta-cognitive/emotional reflection (learning from doing). We are particularly interested in the potential for play to create favorable conditions for developing transversal skills by enabling (i) focused experiential learning, (ii) low-stakes experimentation, (iii) rapid feedback, (iv) opportunity for reflection. In the interviews, the potential to teach conceptual disciplinary knowledge

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dominated teachers' perceptions and transversal skills were sidelined. Focus group participants, just after a hands-on activity, primarily addressed transversal procedural skills in their comments and overlooked the conceptual knowledge underpinning these skills. The importance afforded to meta-cognitive and meta-emotional reflection varied greatly amongst teachers. Our analysis suggests that the three-level model can assist teachers by providing a structure to ensure each level is accounted for in experiential activities. We see promise for addressing transversal skills including sustainability, risk assessment, ethical reasoning and emotional regulation.

1 INTRODUCTION

While there is broad agreement about the importance of integrating transversal skill development in engineering curricula both within higher education and in society at large, that it is a major focus of research communications suggests that it is not trivial. In addition to relying on knowledge outside most teachers' disciplinary expertise, transversal skills are inherently procedural. This means that the process itself is of primary importance, something often overlooked when students' learning is assessed by the final product. Thus, while projects should support the development of students' transversal skills, the format of the feedback and assessment engineering students encounter in projects typically does not favour learning these skills. Another aspect that appears to undermine the development of transversal skills is that students are rarely prompted to reflect on the process. To bring greater visibility to each type of thinking, we identify three aspects for skill development: conceptual knowledge, procedural skill and meta-cognitive/emotional reflection.

This article reports an empirical study at a large, research-intensive Swiss engineering school investigating teachers' conceptions of what students need to learn transversal skills and opportunities afforded by playful approaches. Our objective with this exploration is not to establish the actual benefits or barriers, but rather to understand teachers' conceptions of these issues with a view to providing support that addresses their concerns. In the following section, we present our framework for structuring activities for teaching transversal skills and review the literature using playful approaches in higher education.

1.1 A framework for structuring activities for transversal skill development

Transversal skills involve both knowing (conceptual knowledge) and know-how (procedural skills). Taking the transversal skill of "project planning" as an example, students need to know the names, steps and relative merits of different project planning tools and strategies. Developing students' procedural skill to effectively apply their conceptual knowledge requires them to have opportunities to, for example, select and employ project planning tools. There is no shortage of ways to make conceptual knowledge available to students (books, lectures, videos…) and engineering programmes are increasingly adopting project- and challenge-based approaches that provide students with practical opportunities to use procedural skills. When these experiences incorporate authentic constraints, they offer excellent opportunity to integrate transversal skills with disciplinary thinking. However the number of different things going on in parallel can impede students' capacity to attend to the transversal skills. This lack of visibility is exacerbated when feedback and assessment activities do not explicitly include transversal skills. The result is that students do not acquire skills, such as teamwork, by working in environments where

such skills are needed (Picard et al. 2022). Indeed, it has been exhaustively documented that transversal skills must be explicitly taught in order for students to develop these skills (see Lehmann et al. 2008).

A further barrier to developing transversal skills is that the curriculum is often not designed to encourage students to transfer skills developed in one context to other contexts (Tormey and Isaac 2022). Given that equipping students with transversal skills that they can apply in their future projects and across their professional life is a key motivation for teaching these skills, transfer should be a central concern. An important mechanism for enabling transfer is meta-cognitive and meta-emotional reflection, where students think about their thinking or emotions. This meta-thinking enables us to better recognise patterns and has been identified as fundamental professional skills for solving non-routine problems, managing lifelong learning and interpersonal relationships (Shuman et al. 2005). Students typically require explicit prompts to engage in *learning from doing* meta-cognitive and meta-emotional reflection (Steele, 2018).

Our framework (Figure 1) provides teachers with a structure for learning activities targeting transversal skills. The first of the three levels is conceptual knowledge, identified as the factual knowledge and concepts that underpin a skill. Taking ethics as an example, being able to describe the impact of bias in teamwork. Continuing this example, procedural skills level could be leveraging conceptual knowledge to employ strategies for equitable teamwork. Metacognitive and meta-emotional reflection is the third level and refers to self-monitoring activities around the implementation of the conceptual knowledge and procedural skills. One example would be students comparing their experience of one decision-making strategy to what they used the preceding week. Thinking about both the process and the result improves our ability to identify when an approach works well and when to switch strategies. This type of reflection is fundamental to students transferring the skills they learn to their next project.

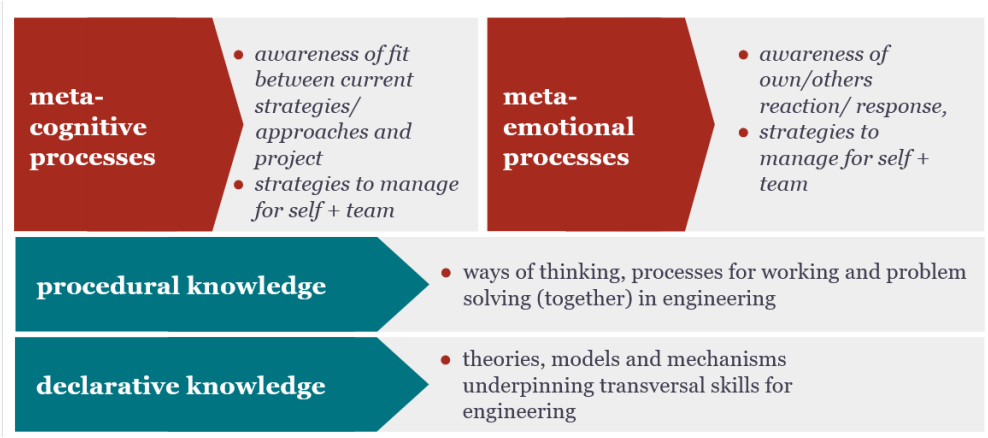

Fig. 1. 3-level approach to I transversal skills

While the development of transversal skills requires students to experience all three types of thinking, our model does not imply temporal order. Indeed, experiential learning may involve students accessing conceptual knowledge only after they realise its relevance. Our framework strives to make the development of a transversal skill more explicit for teachers such that they can ensure that students encounter activities that prompt thinking at each level.

1.2 The case for playful approaches to teaching transversal skills

Play allows us to experiment, to see new things and to try new things - highly useful conditions for learning. Furthermore, play can get us to take on challenging and frustrating experiences while decreasing the potential risks of failure from experimenting. Bodnar et al.'s recent review in engineering education found broad consensus among teachers that games are useful learning tools (2016). While the demarcation is not rigid, numerous scholars have articulated the distinction of formal, rule-based play (which includes games and gamification) from more improvisational and open-ended play such as with LEGO blocks or role playing. Despite the apparent trend towards games in engineering education (Bodnar et al. 2016), we see opportunity to leverage play to create experiential activities focused on transversal skills.

Our interest in the value for play to address a broader set of engineering skills is coherent with Nørgård et al.'s (2017) and Bodnar et al.'s (2016) characterisation that play-based learning supports (i) focused experiential learning, (ii) low-stakes experimentation, (iii) rapid feedback, and (iv) opportunity for reflection. Indeed, the process-driven approach central to play is ideally suited to learning transversal skills. This is a marked contrast from engineering programs' typically product/outcome oriented activities, such as problem sets or building robots, that can obscure the transversal skills. The result is salient for transversal skills currently under addressed in engineering education, such as systems thinking, collaboration, and emotional regulation (Bodnar et al. 2016, Kovacs et al. 2020).

2 STUDY METHODOLOGY

2.1 Data Collection Protocols

To explore teachers' conceptions about teaching transversal skills, we chose the qualitative methodologies of interviews and post-activity focus groups. Guided by the questions in Table 1, we employed a semi-structured approach to investigate participants views and omissions (Kvale and Brinkman, 2009). Approval was obtained from our institutional research ethics committee (038-2022).

Table 1. Interview (1-4) and Focus Group (5-8) Questions

1. What is « play» in Higher Ed in an institution like EPFL?	5. What is one benefit and one disadvantage for student learning using activities like in this workshop?
2. In your view, what are the benefits of play in higher education teaching? Do you see any challenges or potential drawbacks of play?	6. Focusing on students' transversal skill development, could activities like this be useful in your course?
3. Do you use play or playful strategies in your teaching? How would you describe them? Do these activities target specific skills and/or content?	7. In the activity we did, what transversal skills do you think were developed? What actions or moments supported this development?
4. Overall, how would you describe your experiences with play in higher education settings, if any?	8. Is this activity playful to you? Would you describe this type of activity as playful to your students?

Interviews were conducted individually by Author 1 or 2; median time 35 minutes. Roughly half the interviews took place on campus, the others on Zoom. Focus

groups were held on campus, sandwiched within workshops demonstrating an activity targeting transversal skill development and the presentation of our 3-level framework. Author 1 and 3 conducted the focus groups, median time 30 minutes. In all cases, participants received the information sheet and consent form in advance.

2.2 Participants

In Fall 2022, we used a purposive approach to identify teachers from diverse disciplines teaching a range of classes (20-400 students). All seven teachers responded positively to our email request to be interviewed and were assigned names (not starting with F) according to their preferred pronouns. Two teachers (Diana and Isabella) reported using playful approaches and two (Joseph and Mario) used gamified approaches in their teaching. In Spring 2023, we organised two workshops to demonstrate a playful experiential activity using tangibles to teach feedback literacy. The activity was immediately followed by a group discussion. 16 of the 19 people who attended agreed to be recorded. Their demographic profiles represent a range of diverse disciplines, teaching experience and institutional roles. Focus group participants received names (starting with F) based on our interpretation of the audio recording.

2.3 Data Analysis

Transcribed audio recordings were imported as text files in Dedoose qualitative analysis software. We proceeded with an inductive approach to analyzing interview data and a deductive approach for the focus groups. Authors 1,2,3 each performed a preliminary reading of 2 transcripts, identifying interesting extracts with thematic coding. A coordination meeting between authors 1,2,3 served to make a more coherent code book which was then applied exhaustively. Authors 1,2,3 each assumed responsibility for certain themes and re-read all the transcripts to ensure that all relevant instances were captured.

3 FINDINGS

3.1 Teachers' conceptions on teaching transversal skills

While our expectation was that teachers would be least aware of the importance of the meta-cognitive/emotional reflection activities, we were struck by how infrequently the conceptual knowledge underpinning transversal skills was mentioned by teachers. Interview participants, who did not experience the activity, focused primarily on the potential for students to learn conceptual disciplinary knowledge through playful approaches. This was very different for focus group participants who largely neglected conceptual knowledge in their comments. Only Felicia (i), Frida and François stated that the hands-on activities either required or were deepened by providing students' with tools, concepts or models to apply. Faye (ii) cautioned that teachers' may not have the foundational conceptual knowledge about the transversal skills, or the procedural skills, to enable them to be comfortable teaching transversal skills. Other participants in the study did not address the importance of conceptual knowledge related to transversal skills before the three-level model was presented to them.

> *it's a very good complimentary activity to go along with some other self-awareness tools, to have a combined conversation – Felicia (i)*

> *we cannot expect them to teach something that they themselves don't have, and don't know – Faye (ii)*

The procedural skills of level 2 were highly visible to the focus group participants who experienced the hands-on activity. These teachers appreciated the opportunities the activity created to 'see' where and how transversal skills were relevant. In one group, there was an interesting discussion about if separate activities were preferable to integration into activities already part of a course. The consensus was that it was easy to lose sight of these skills even when they were the sole purpose of the activity. Participants seemed to agree that the best approach was short activities focused on specific transversal skills in a course where they had the context to apply them more widely. The advantages of 'zooming in' on specific skills in lower-stakes environments in parallel to a course project, for example, were attractive to teachers.

> *someone naturally takes the lead in the group. It always happens… I find [this activity] very suitable for my group of students - Frida (iii)*

> *It allowed people to trial, to test, make mistakes. There were less risks for them. That was a good opportunity for them to understand, to be able to learn what works, what doesn't work – Frederic (iv)*

> *I don't know how much, as a student, I would be able to transfer to paying attention to the feedback if I were in another context. – Franz (v)*

> *the activity is disconnected from other things. So the opportunity is there. The fact that it is disconnected is good. – Fabienne (vi)*

For some focus group teachers, the high visibility of the procedural activities may have obscured the 'desirable difficulty' of having students encounter authentic challenges to allow them to develop appropriate skills. Frida's comment (vii) below illustrates a recurrent example of this where teachers suggested that the feedback literacy activity we demonstrated could be used to constitute student teams with low potential for friction. Conversely, Frank's comment (viii) demonstrates understanding that encountering challenges, such as unequal participation or difficult feedback, is desirable because it creates learning opportunities.

> *[students] can decide, based on the feedback [they] got and the experience [they] got, who to team up with – Frida (vii)*

> *I would have wished to have been pushed a little bit more out of my comfort zone… If you could find a way to make a little bit more of a critical experience, to go deeper into it, to go into the emotions – Frank (viii)*

Teachers' comments about the meta-cognitive/emotional activities were diverse. Some teachers, such as Felix (ix) and Fatima, expressed concern that if students were not actively involved in the activity then they would not learn. They did not appear to understand that when a session includes a metacognition/emotional activity, the authentic experience of having different levels of contribution to the team, feelings of exclusion and acts of inclusion provide rich material to reflect and learn. Other teachers, Felicia (x), Faye (xi) and Frank, did identify the value of reflection activities.

> *[some students] may be in the group but not really interact. And you may lose, well not lose them, but see that they are not learning from the activity – Felix (ix)*

> *that's something really interesting to discuss afterwards. You know, self-awareness, how we act under time pressure…. People jump right into [the primary task] and that's something to debrief about – Felicia (x)*

I realised after only because we had this very quick and easy check… even though we knew that this was a workshop to develop the skills – Faye (xi)

3.2 Teachers' conceptions of benefits and challenges of playful approaches

With one exception, teachers were positive about the value of playful approaches, primarily due to their conception that such activities increase students' motivation for learning but also students' learning itself (Joseph xii, Mario xiii). Two teachers expressed an interest in research evidence about the impact of play in higher education (Isabella, Mary xiv).

it allows them to explore these topics in a more playful way and then also compete. Right? It's fun to be the best... – Joseph (xii)

I think it was my own interest, to really make sure that I can maximize the number of students that I have that can learn something. – Mario (xiii)

any studies related to the impact that it has on learning. I think it's very good for professors to also see this. Because if we think that it will be impactful in our teaching, then we're going to be more likely to implement it. – Mary (xiv)

Experiencing the benefits of play themselves, either as a participant or a facilitator, was cited by interviewed teachers with positive dispositions towards playful activities (Sara xv). Interview participants focused on conceptual disciplinary knowledge.

So at the beginning, yeah, I was skeptical. And then when I saw the result, I was quite enthusiastic. – Sara (xv)

Teachers also expressed some concerns about using more playful approaches in their classes. The concern Mary (xvi) expresses about the effort of creating or adapting activities was mentioned by several teachers. In particular, teachers' belief that an activity should be relevant to students and well integrated in the course led them to conclude that it would require significant effort. Isabella and Joseph, who both use playful strategies in their teaching, mentioned difficulties with assessing what students actually learn. Teachers not using play did not perceive this issue.

We're so freaking busy doing so many things, it's really difficult. [...] But yeah, I would actually love to do that and explore it. – Mary (xvi)

If [students] don't have the impression that it was efficient, then I think you lose your credibility. And you also lose time, and you lose people's time also. - Sara (xvii)

4 DISCUSSION AND CONCLUSION

Engineering programs laud their graduates' future contributions to resolving the environmental crisis, an endeavour that requires students to have the skills to understand and lead complex interdisciplinary approaches (Akins 2005) that incorporate engineering expertise with sustainability, economic policy, and cultural awareness. The current transversal skill level of engineering graduates is not adequate to these lofty ideals (Craps et al. 2017, Torres et al. 2018). Developing students' transversal skills may require teachers to both acquire knowledge and employ teaching strategies beyond those they currently master.

In this article, we present our three level framework for structuring learning activities to develop transversal skills and employ it to examine teachers' conceptions about teaching transversal skills. Applying the model as a lens allowed us to characterise

teachers' conceptions about teaching transversal skills. In the interviews, teachers repeatedly pivoted to disciplinary conceptual knowledge even when discussing hands-on activities. In the focus groups, which were preceded by a playful activity, teachers consistently overlooked the conceptual knowledge underpinning the transversal skills and often equated the procedural experience with skill development. This was reflected in the teachers' heterogeneous awareness of the role and value of metacognitive/emotional reflection.

Our observations are coherent with the previous identified conception that experience equals learning, despite prior work establishing that transversal skills must be explicitly taught (Picard et al. 2022, Lehmann et al. 2008). The persistence of this erroneous assumption likely contributes to teachers proposing courses that require transversal skills without providing students with the associated conceptual knowledge or prompts for reflective activities (Steele, 2018) to truly develop their transversal skills.

Needing to provide conceptual knowledge about transversal skills may increase teachers' concerns about dislodging core disciplinary material and the discomfort of teaching skills outside their own expertise. Yet teachers who experience playful strategies report that seeing the impact on learning reinforced their interest in using such strategies themselves. An important limitation of this observation is absence of representativity in this study population. Interview participants were invited and focus group participants chose to attend a workshop about teaching transversal skills. However, the selection bias of participants only emphasizes our finding that experience alone was insufficient for teachers to accord importance to all three levels present in our model. While most teachers expressed a willingness to embed transversal skills in their courses, many expressed the need for support to do so. Our model provides teachers a structure to ensure the three types of learning activity necessary to develop transversal skills are all addressed.

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