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Supporting Students' Learning and Development of Transversal Skills Through a Training Portfolio Approach

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ABSTRACT

Despite the recognized importance of transversal skills beyond technical knowledge, unless process goals are being made explicit for learning, students engaged in project-based learning tend to give priority to final deliverables over the transversal skill development (such as project management, team collaboration and management, documenting their work, and awareness and regulation of emotions). This study employed a mixed-methods case study design involving approximately 60 engineering students from different backgrounds enrolled in a two-semester Social Sciences master's course that used structured training portfolio assessment within the team project.

In addition to the engineering project work and the deliverable, the training portfolio model required students to complete three phases: initial competency planning supported by the Interprofessional Project Management Questionnaire (IPMQ), ongoing process analysis and reflection tasks, and final assessment through reflective summaries. Quantitative analysis demonstrated statistically significant and relevant improvements in all four IPMQ dimensions, with the strongest effects observed in interprofessional communication and project planning, followed by risk analysis and ethical sensitivity. Qualitative analysis of portfolio content revealed alignment between intended curriculum outcomes and student learning experiences, with documentation, project management, and team management emerging as the most frequently addressed competences.

The convergence of quantitative and qualitative findings provides evidence that the training portfolio approach successfully directs student attention toward process-oriented learning objectives. The use of the training portfolio is thus a viable pedagogical strategy offers a viable solution for systematically developing transversal skills in group projects, while maintaining focus on technical project deliverables in engineering education contexts.

KEYWORDS

Transversal skills, Project-based learning, Training portfolios, Ethical sensitivity, Reflection, Self-efficacy beliefs, Cognitive and emotional processes

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Introduction

Contemporary engineering education recognizes the necessity of developing transversal skills that extend beyond traditional technical knowledge. Engineering accreditation bodies, including Accreditation Board for Engineering and Technology (ABET) in the United States and The European Network for Accreditation of Engineering Education (ENAEE) at the European level, require that engineering programs systematically develop transversal skills alongside technical expertise (Shuman et al., 2005). These skills encompass the ability to plan and manage processes for complex problem-solving, work effectively in diverse teams, consider ethical dimensions and potential risks, and become self-directed, lifelong learners (Shuman et al., 2005; Cruz et al., 2020; Picard et al., 2021), and have also been proposed as the basis to prepare the future engineers for the VUCA world (European Society for Engineering Education [SEFI], 2025)..

Project-based learning (PBL) is an important pedagogical approach that can respond to this educational mandate. Defined as a method involving students in design work, problem-solving, and decision-making, PBL provides students with opportunities to work autonomously and produce realistic outcomes (Jones et al., 1997; Thomas et al., 1999). This approach is characterized by authentic content, explicit educational goals, cooperative learning, reflection, and the integration of transversal skills (Diehl et al., 1999). Furthermore, the widespread adoption of team-based projects in engineering curricula reflects institutional recognition that students require experiential learning opportunities to develop such complex competencies (Howe et al., 2017).

However, a fundamental implementation problem undermines this pedagogical strategy. Despite acknowledged benefits of project-based curricula, research consistently demonstrates that, unless curricular scaffolding elements are available in the educational environment with the process goals being made explicit for their learning, there is a risk that students engaged in complex, open-ended design projects tend to give priority to final deliverables over the processes of critical thinking and transversal skill development (Picard et al., 2021). This outcome represents more than just a missed educational opportunity - —it constitutes a systematic failure to achieve core learning objectives such as transversal skills that project-based approaches have the potential to attain.

The Challenge of Learning Transversal Skills in Engineering Projects

The challenge of developing transversal skills through project-based learning stems from several interconnected factors. First, instructors who possess these skills have often internalized them to such a degree that they struggle to articulate what these skills entail - —a phenomenon known as the 'curse of expertise' (Tormey et al., 2021). Second, while the conceptual foundations of transversal skills may be straightforward to describe, their practical application is complex and requires extensive practice, feedback, and reflection to develop transversal skills effectively.

Educational theorists from Dewey and Lewin to Kolb have emphasized that students cannot be expected to learn from experience alone, but rather from the ability to step back, consider their experiences, identify patterns, connect them to theoretical concepts, and then re-engage with their practice (Tormey et al., 2021). This process, typically referred to as 'reflection' in educational literature, is often only tacitly and vaguely understood, even in disciplines more closely aligned with humanities and social sciences (McGarr & McCormack, 2014).

The complexity deepens when considering that students in engineering projects must simultaneously learn two fundamentally different types of competencies. Projects typically require students to develop or apply technical knowledge to produce tangible artefacts that are clearly recognizable as engineering products and are formally assessed. Concurrently, students are expected to develop ill-defined tacit skills, such as transversal skills, which may be difficult to demonstrate, are often perceived as external to 'engineering', and frequently remain unassessed (de Lima et al., 2024a; de Lima et al., 2024b; Jalali et al., 2022). Given the cognitive load constraints that students face (Tormey et al., 2021), it becomes evident that the technical skills still receive priority attention. This challenge is further compounded in team projects, where maintaining team dynamics demands additional cognitive resources (Kirschner et al., 2011), further reducing students' capacity for reflection. Therefore, while there is agreement that the transversal skills are relevant and complex to learn, there is one additional issue: how they should be taught and assessed, or indeed, whether or not these skills can be taught and assessed (Shuman et al., 2005).

The confluence of these factors creates a practical barrier to transversal skills development. Students encounter difficulty learning transversal skills because: (1) these skills are often not explicitly defined, making it difficult to direct attention and focus learning efforts; (2) the learning process through reflection is itself poorly defined and challenging to operationalize effectively; (3) reflection appears disconnected from students' understanding of engineering learning; (4) students are focused on producing tangible engineering artefacts and deliverables rather than process-oriented goals; and (5) assessment practices typically emphasize technical knowledge demonstrated through artefacts rather than the tacit transversal skills that students develop through project work.

Portfolio Models as a Pedagogical Solution

Portfolios present a promising strategy for addressing this complex set of educational challenges. They have been Uused for decades in a wide range of disciplines from medical to vocational education (Backer, 1997; Clausen & Garcia, 2000; Cotta et al., 2011; Simatele, 2015; Yielder & Moir, 2016). Furthermore, portfolios have been recognized for their ability to capture the complexity of transversal skills more effectively than traditional assessment methods while simultaneously providing structured opportunities for reflection and collaborative learning (Lomask et al., 2018).

There is converging evidence across recent engineering education research – frequently developed within CDIO programs – that portfolios constitute an effective pedagogical instrument for fostering transversal skills development. Kawasaki et al. (2022) report that portfolio education, supported by the objective assessment of generic skills, allows students' competences to be systematically tracked, made visible, and progressively developed across an engineering curriculum, while Ketola and Kontio (2022) show, through their curriculum framework for project-management competences, that transversal skills such as planning, coordination, and team leadership can be deliberately structured and developed across a programme rather than left to incidental learning. Doulougeri et al. (2021), through a content analysis of first-year students' learning portfolios in a challenge-based learning course, demonstrate that portfolios scaffold self-regulated learning by externalizing the cycles of goal-setting, monitoring, and self-evaluation that underpin the development of transversal skills such as teamwork, communication, project management, and reflection. In a department-wide study of project-based courses, Hansen and Sindre (2023) similarly observe that portfolio-based assessment — combining reports, reflective notes, demonstrations, presentations, and artefacts — has become the dominant form of summative evaluation precisely because it accommodates both technical and generic learning outcomes, including the often hard-to-assess collaboration and communication skills. Kyas, Foley, and Foley (2023) further argue that the reflective-writing component of such portfolios supports the development of interpersonal and metacognitive skills, including self-awareness, emotional literacy, and the early identification of team-based difficulties. Building on these arguments, Moreno, Decker, and Leicht-Scholten (2024) demonstrate, through a qualitative content analysis of student reflections, that a project-based portfolio examination in an interdisciplinary engineering course enabled students to develop a broad spectrum of competences described in the CDIO Syllabus 3.0, including critical and systems thinking, teamwork, communication in a foreign language, and ethical and sustainability reasoning. Finally, Tang et al. (2025) describe a developmental portfolio system, supported by a learning analytics dashboard, in an aerospace engineering master's programme designed specifically to track and provide feedback on transversal skills alongside disciplinary knowledge, noting that portfolios afford particular advantages for self-regulated learning, reflection, and developmental - rather than purely summative - assessment. Taken together, these studies suggest that portfolios are not merely a record of student work, but a pedagogical mechanism that renders the development of transversal skills visible, assessable, and reflectively integrated into the disciplinary curriculum.

However, the term 'portfolio' encompasses diverse approaches that serve different educational purposes. Common elements across portfolio models include the collection of evidence demonstrating learning or achievement in authentic settings, active learner involvement in determining documentation content and methods, frameworks supporting student reflection, and opportunities for formative assessment during the learning process rather than solely as an end product (summative assessment) (Smith & Tillema, 2003).

Smith and Tillema's typology identifies four distinct portfolio approaches (depicted in Figure 1): (a) a dossier consisting of required work pieces demonstrating specified competences; (b) a training portfolio comprising required exhibits collected during a learning program to demonstrate competence development; (c) a reflective portfolio featuring student-selected work demonstrating growth over time, often used for program admission; and (d) a personal development portfolio containing exhibits selected to articulate personal growth narratives.

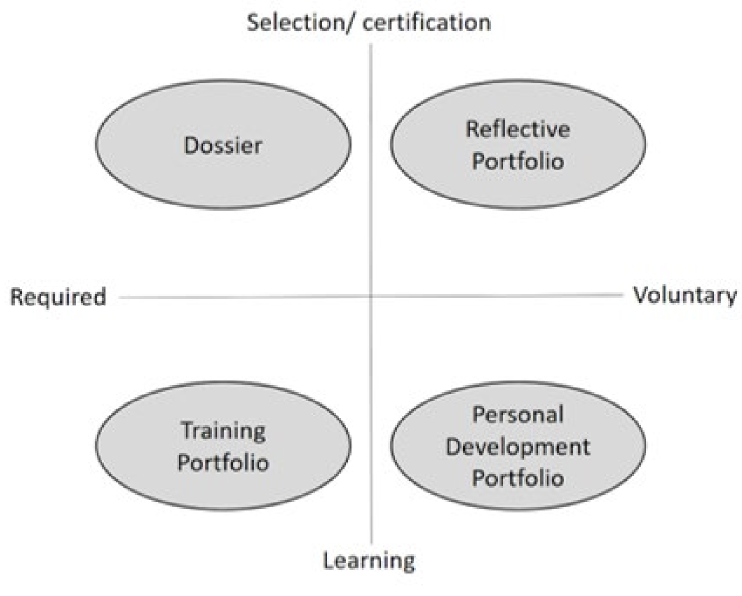

Figure 1: Smith and Tilema Portfolio typology (Smith & Tillema, 2003)

This typological framework explicitly links the portfolio format to educational objectives, highlighting that effective portfolio implementation requires alignment between structure and intended outcomes. Indeed, the portfolio approach was linked with measurable improvements in a range of professions, provided that its design and integration are carefully aligned with the proposed educational objectives

(Clausen & Garcia, 2000). For the development of transversal skills in engineering education, the training portfolio model offers particular promise as it documents skill development while maintaining focus on competence acquisition. Rather than functioning only as a repository, the training portfolio systematically directs attention towards the learning processes happening in parallel to technical project development.

While training portfolios provide a flexible framework for supporting transversal skill development, CDIO-based engineering education has also employed more structured project-process models such as LIPS to support students' development of project management, communication, and documentation skills through milestone-based project organisation and supervisor feedback (Wetterö et al., 2006; Rosqvist et al., 2008). However, such models are often closely tied to specific project-management traditions or disciplinary contexts. In our setting, where students came from diverse engineering backgrounds, we therefore sought an approach that could accommodate different project practices while still supporting structured reflection on learning processes and transversal skill development.

Aims, Study Objectives, Questions and Contribution

This study describes and evaluates a training portfolio approach designed to deliberately redirect students' attention toward process-oriented learning objectives. By implementing this model, the course designers aim to create a more holistic learning environment that not only produces engineering artifacts but systematically cultivates the transversal skills essential for contemporary engineering practice.

Our work focuses on investigating the development of transversal skills among master's level engineering students at a technical higher education institution in Central Europe. Through this empirical investigation, we seek to contribute insights into pedagogical strategies that can more effectively bridge the gap between academic project work and transversal skill development.

We build upon our earlier efforts (Kovacs et al,. 2023) in which we explored how the intention to teach certain transversal skills leads to what students learn, and how the use of a portfolio as an assessment tool supports this process. More precisely, we previously investigated how the transversal skills were represented in the different parts of the curriculum. In the present study, we go one step further to ask if the training portfolio as a tool used for assessment influences the development of transversal skills over the duration of a course.

Engineering education frameworks have long recognized that PBL environments, while capable of developing transversal skills, do not automatically do so: the goal-framing and assessment mechanics that reliably redirect student attention toward process-oriented competencies remain underspecified in the literature (CDIO Initiative, 2022a; 2022b; Crawley et al., 2014). The present study responds directly to this gap. By introducing a training portfolio as a structured scaffolding instrument, it operationalizes the dual imperative - —developing both technical and transversal skills - —that accreditation bodies and curriculum frameworks have articulated but that pedagogical practice has struggled to reliably achieve.

Our focus in this practice paper is to describe the rationale behind the approach to address this issue, and to document our practices in a way that would allow others to adapt and adopt them for their own setting. In order to give some confidence that these practices may be useful in addressing this issue we also sought to collect data on the impact of the portfolio activity. The data was collected to respond to two questions: (1) how are transversal skills represented in students' reflections in the portfolios? and

(2) Is there any evidence that students' sense of self-efficacy in relation to transversal skills develops when they use the portfolio?

The subsequent sections will detail our methodology, present our findings, and discuss the implications of our training portfolio approach for transversal skills development in an engineering education context.

Methodology

Context

The course we describe for this case study belongs to the social sciences courses at a technical European university. The course is offered to first-year master's students from all master's degree programs (including a wide range of engineering programs such as mechanical, electrical, civil, environmental, computing, life-sciences, and financial engineering, among others) as an accredited elective two-semester course (3 ECTS credits per semester, 6 in total). Each student is expected to spend 4.5 to 6 hours per week on the course, during 14 weeks of each semester. The course focuses on the design of a learning tool. Students are free to choose the content to be taught through the learning tool, the functionality of the learning tool and the target audience for the tool use. Many student groups develop digital tools (online games or teaching resources) but some design other types of learning activity (e.g. escape games, pedagogical board games, magazines, traditional exercise and lecture materials). The course is structured around lessons on aspects of team and project management (ideation activities, decision-making activities, group communication skills, risk analysis exercises, conflict management etc.) which accompanies the project-based learning in which students work in teams with colleagues from different backgrounds. For this course, a specific subset of transversal skills was chosen as intended learning outcomes (Appendix 5), based on the institutional list of 32 transversal skills, organized in five competence families, is provided in Appendix 4.

One example of how teachers have tried to make the project management process explicit to students is the LIPS model, developed in the CDIO context at Linköping University and adopted in a number of universities and engineering courses (Wetterö et al., 2006; Rosqvist et al., 2008). LIPS describes a clearly defined project management process structured around 'milestones' and 'tollgates' across the project timeline, with documents tightly tied to the development process and reviewed by supervisors — thereby contributing to the development of communication and documentation skills alongside the project deliverable itself. While valuable, LIPS represents only one of many available project management models (waterfall models, agile models, and others), often associated with specific disciplinary traditions. In our context, with students coming from a wide range of engineering disciplines, providing a single project model such as LIPS would not have accommodated this disciplinary diversity. We therefore opted for an approach less tied to any single project management model, but which encouraged meta-reflection on students' diverse project management processes — for which the training portfolio described below was particularly well suited.

The course requires students to submit a report (corresponding to a typical deliverable the students encounter in engineering projects) and a training portfolio (corresponding to a reflective exercise on the project and team development, as well as personal appreciations of the learning). To accomplish this, the student teams are supported through a set of on-demand coaching sessions with a project coach (the teaching staff). More precisely, the students go through the following phases over the duration of the course: In phase 1 they perform the Scoping and Planning of their project, including literature reviewing, brainstorming, deciding, planning, time budgeting, internal risk analysis, external risk analysis, report writing. In phase 2, they perform the Developing, including brainstorming, deciding, time budgeting, developing, prototyping, report writing. The final phase has to do with the Project Presentations (this is also the phase when they complete the process analysis of their work on the project).

Assessment in this course is both summative and formative (as each deliverable also serves as a learning support): a preliminary report on the technical aspects of the project, prepared as a group (30% of the final mark); an educational artefact and accompanying report on the development of the artefact, prepared as a group (50% of the final mark); a process analysis (training) portfolio in which students individually analyse the way their group works, and propose ways of improving the group's functioning (20% of the final mark). In the present study, we focused the part of portfolio that targets the development of transversal skills.

This case study involved the analysis of the curriculum and qualitative and quantitative sources of data found in course artefacts, across several time points. We used a mixed-method approach for its design and data collection as well as for the analysis and the interpretation of the results. In the first stage (taking place in the years 2022 and 2023), we examined the learning and teaching goals across the curriculum; this qualitative part included both a student perspective (an analysis of portfolios) as well as a teacher perspective (interviews), as detailed in a previous report (Kovacs et al., 2023). In a second stage (taking place in 2023), we evaluated the learning and student outcomes through. the use of training portfolios as learning and assessment tool. This stage included both a qualitative (analysis of individual portfolios) and a quantitative analysis (self-efficacy beliefs of transversal skills). The second stage involves a course that has slightly changed compared to the first stage, namely the slight changes to the structure of the portfolio (Appendix 1).

The Portfolio as an assessment tool

The portfolio type used in this course is a training portfolio according to Smith and Tillema's (2003) typology. A training portfolio consists of required exhibits which are collected during a learning program to demonstrate competence development. The first part is a planning process where students identify what competences they would like to develop over the duration of the course. The Interprofessional Project Management Questionnaire IPMQ (Tormey & Laperrouza, 2023) scores are used as a support for their reflection, but planning is the primary purpose. In the second part of the portfolio students complete a series of reflection or "process analysis" tasks. These involve the collection of data on their team or project management, the analysis of the data, a reflection draw conclusions on how to improve their team or project management, and discussing these conclusions with their teammates. Each team member is responsible for one process analysis, but all team members include each other's process analysis as exhibits within their portfolio. The third and final part of the portfolio is the only part that is assessed and it includes a tabular summary of previous ungraded reflections, with a particular focus on the change of practice, and two reflective questions related to learning about group management and project management (Appendix 1).

In completing the reflective blocks of the portfolio, students are guided by prompting questions and invited to record their meetings to document their thinking and reflections. In providing instructions for completing the portfolio, it is explicitly stated that the assessment will focus on the quality of students' reflections regardless of whether the desired learning is achieved or not. This means that the grade is given on the basis of the quality of student reflection, rather than the acquisition of a skill

(Appendix 2). This is an attempt to encourage students to present honest reflections, rather than to satisfy the teacher's expectations.

A team-level reflection at the end of the project process is also a feature of the LIPS model, in which a collectively written Project Reflection document forms part of the closure phase (Wetterö et al., 2006; Rosqvist et al., 2008). The reflection embedded in our portfolio is similar to LIPS in some respects: both invite students to look back on their collaboration as a team and on the way they have managed the project process. Our model, however, incorporates two additional elements of reflection: (i) attention to the emotional processes that students experienced over the course of the project, and (ii) attention not only to what students learned but to how they learned it. This reflects our underlying intention to support students in becoming more intentional in the management of their own cognitive and emotional processes through such reflection tasks.

Sample and Procedure

Approximately 60 master students from diverse engineering backgrounds, enrolled in the above-described social sciences course, participated in a group project focusing on designing a specific solution to an open-ended problem. During the project, the students were required to submit several reports that focused on the process they were going through. The final document was a portfolio compiled at the end of the project, and served as part of the assessment to strengthen skills development.

The quantitative approach

Students also completed an online questionnaire about the transversal skills involved in the project work and received an automated feedback report that explained each assessed dimension with their individual score. As mentioned earlier, IPMQ (Tormey & Laperrouza, 2023) was used to assess the self-efficacy beliefs about transversal skills, employing the original validated scale in its full form, including its item count, subscales, and scoring.

Internal consistency was assessed using Cronbach's alpha. For Risk Assessment, reliabilities are reaching acceptable recommended levels ~.70 (Taber, 2018) at T1 ($\alpha = .76$, 3 items, $n = 55$) and even exceeding these at T2 ($\alpha = .78$, 3 items, $n = 42$). A similar picture is shown for Ethical Sensitivity with an acceptable internal consistency at T1 ($\alpha = .70$, 4 items, $n = 55$) and exceeding this level at T2 ($\alpha = .76$, 4 items, $n = 42$). Project Planning showed lower internal consistency at both T1 ($\alpha = .55$, 6 items, $n = 55$) and T2 ($\alpha = .55$, 6 items, $n = 42$). A similar pattern is observed for Interprofessional Communication, showing relatively lower internal consistency at T1 ($\alpha = .61$, 7 items, $n = 55$) and even lower at T2 ($\alpha = .55$, 7 items, $n = 42$). While the guidelines discussed by Taber (2018) are often treated as a pragmatic minimum for research scales, such values should be interpreted cautiously and in context, especially in applied research contexts. The values found in the present study are similar to those of the original questionnaire (Tormey & Laperrouza, 2023): Risk Assessment ($\alpha = .80$) and Ethical Sensitivity ($\alpha = .76$) and slightly lower for Project Planning ($\alpha = .71$) and Interprofessional Communication ($\alpha = .73$).

Data collection was performed through the REDCap platform, hosted on the institution's servers, and employed pseudo-anonymity (using a link generated through the application). Ethics approval was granted by the local Ethical Review Committee (HREC000198 - xxxx) with Informed Consent from the participants to have their answers to the self-report and portfolios contents used for this study.

The qualitative approach

While the core qualitative approach of this project was already described in detail previously (Kovacs et al., 2023), the sources of information for this phase of the project were found at different levels: the written curricular course documents, the IPMQ and the structure of the portfolio, and the student input in their portfolios.

The data analysed in the qualitative part of this study was sourced from portfolios submitted by students as part of their continuous assessment. We have used the same codebook as in the first study (Kovacs et al., 2023) in order to understand changes to the updated course design between the first study and the second study. We used a deductive coding approach and the work was split between the two researchers who worked on it in the first study. The coding was cross-examined and verified by having a section of 20% of coded material that was coded by both coders.

Again, the structure of the portfolio and the IPMQ, both tools which guide students to reflect on and assess their skills, were analysed thematically and focused on transversal skills intended to be developed through the course. Learning was "captured" as explicit and implicit mentions of transversal skills in the individual portfolios. The results were discussed between researchers and processed into the final visual representation. The portfolio had a collective part (group work) and an individual part (assessed and reflective). However, only the data from 34 students belonging to the same group that consented to the study were used, given that some individuals did not consent to their data being used, and each individual portfolio contained reflections from all group members.

Results

Quantitative findings

Before conducting the paired sample t tests, we checked the skewness (values ranged between -0.41 and +0.20) and kurtosis (values between -0.84 to +0.12) for each scale at each time point. The values indicated very little asymmetry (skewness close to 0) and only slight flattening (kurtosis slightly negative), with no meaningful departures from normality overall, supporting the use of parametric t tests.

Results of paired samples T-tests suggest that students perceive a development of the transversal skills assessed with the IPMQ over the duration of this course, that is between week 1 and week 12. Furthermore, this perceived development is not only statistically significant; the magnitude of the effect is also substantial — a finding that carries particular weight given the relatively small sample size (42 respondents). The effect is moderate for ethical sensitivity, strong for risk analysis, and strongest for project planning and interprofessional communication (Table 1). In other words, over the duration of the course, while working in teams on a project and using the training portfolio approach, students perceived that they gained most in terms of interprofessional communication, followed by project planning, risk analysis, and ethical sensitivity.

Table 1: Paired Differences of the IPMQ dimensions reflecting the self-perceived interprofessional skills, where T2-T1 stands for the 12 weeks pre-post interval within the course

				95% Confidence Interval of Mean the Difference				Significance (One-Sided p)	Cohen's d	95% Confidence Interval of the Point Estimate (Effect Size)	
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df		Point Estimate	Lower	Upper
Pair 1 T2-T1 Project planning	.42	.44	.07	.55	.28	6.11	41	<.001	.94	1.30	.57
Pair 2 T2-T1 Risk Assessment	.50	.79	.12	.75	.25	4.10	41	<.001	.63	.96	.29
Pair 3 T2-T1 Ethical Sensitivity	.35	.69	.11	.57	.13	3.27	41	.001	.50	.82	.18
Pair 4 T2-T1 Interprofessional communication	.52	.51	.08	.68	.36	6.57	41	<.001	1.01	1.38	.64

Qualitative findings

The first step in the qualitative analysis was to examine the alignment of the three aspects of the curriculum using the portfolio approach – the intended, the taught and the learnt curriculum (Figure 2). Whereas the initial stage of this project focused on the learning and teaching goals, at this stage, we looked at the learning and student outcomes. We identify several pertinent aspects:

- In the present study, a deductive approach was primarily used to coding based on the codebook from the first study;
- The portfolio had a collective part (group work) and an individual part (assessed and reflective)
- There was one new code in the collective and two in the assessed part - mainly due to the change of the structure of the portfolio

The overall analysis is mapped in Figure 2 to visualize the alignment at specific stages and highlight the coherence and gaps.

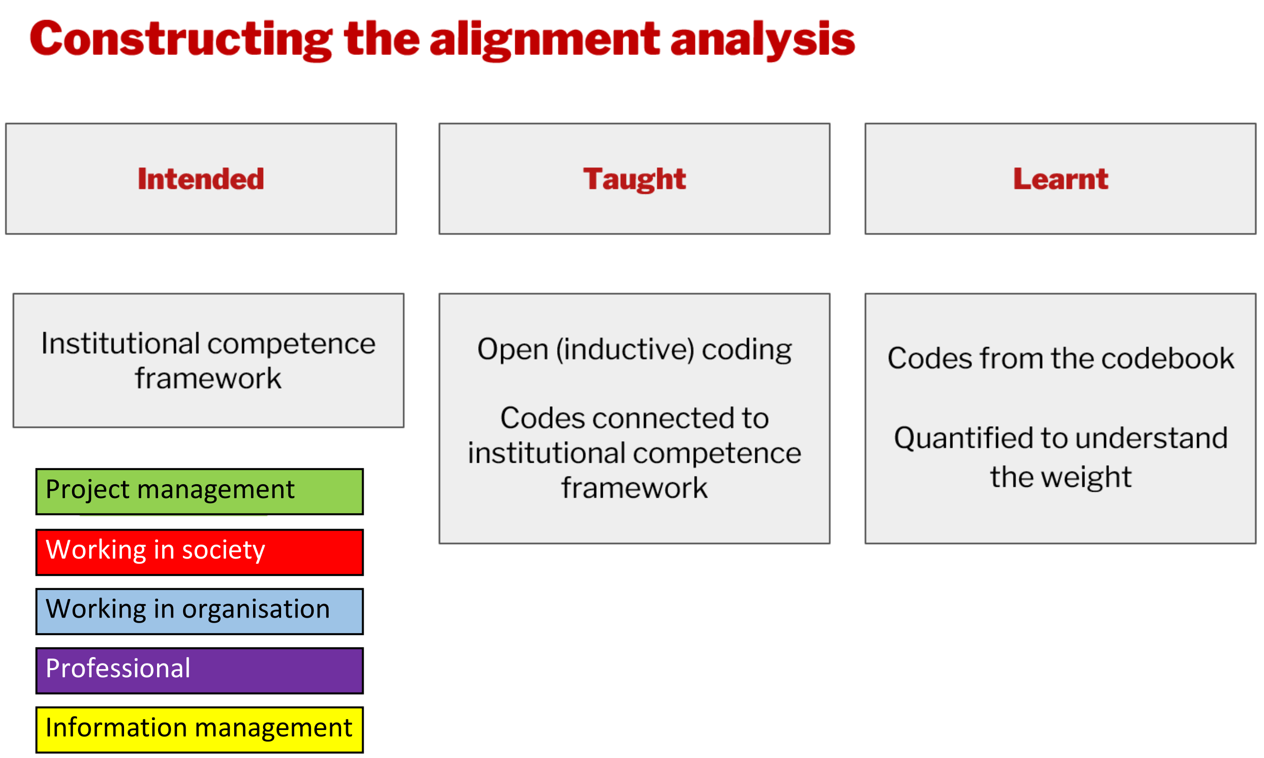

Figure 2: Visualization of the qualitative analysis of the curriculum alignment

In reading the map, we point out that each phrase represents a transversal skill mentioned at a specific point of data analysis. In the first row (intended curriculum), each category corresponds to the institutionalized transversal skill list that teachers use in constructing their course documents and learning outcomes (Kovacs et al., 2020). The colours of the map also correspond to how the transversal skills are grouped into five families, and these five competence families and 32 skills are pre-set by the institution (see Appendix 4 for the full list).

Turning to the individual, assessed part of the portfolio, two notable aspects emerge (Table 2): first, the risk analysis dimension appears less frequently than the other IPMQ dimensions; and second, new aspects emerge that refer to self-regulation and emotional regulation.

Table 2: Counting of transversal skills occurences in the individual (assessed) part of the portfolio (sample size 34)

	Assessed (Individual Part)
Documentation	71
Project management / planning	66
Team management	60
Meeting management	53
Communication (team or project)	47
Collaboration	45
Self-regulation and emotional regulation	40
Time management	39
Team roles	38
Creative (divergent) thinking	38
Decision making	29
Metacognition	27
Empathy / encouragement (ethical sensitivity)	23
Risk analysis	19
Feedback	16
Negotiation	15
Reflection	15
Chairing	11
Data collection	11
Diversity	5
Interdisciplinarity	5
Language skills	3
Conflict	0

Discussion

The purpose of this study was to describe a learning and assessment tool for transversal skills, in the form of a training portfolio, which may be a viable approach in engineering team projects to support the development of such skills in the area of team management and project management.

The quantitative findings indicate moderate to large increases in students' self-efficacy beliefs over the course of the semester. While we cannot rule out that this development is simply due to the maturation of students' experiences over time, evidence from prior studies (Picard et al., 2021) shows that students' scores in IPMQ do not typically increase when working on a project unless there is some specific learning intervention to draw their attention to these skills.

The qualitative findings indicate that the competences students saw as being developed over the course were also largely those that they devoted time to in the reflections and process analyses. These included communication (communication, meeting management) and project management (documentation, project management), and ethical sensitivity (empathy). The qualitative analysis additionally reveals novel dimensions and granularity not captured in the quantitative framework, particularly highlighting the critical influence of inquiry methodology on student responses. This finding underscores the methodological sensitivity inherent in competency assessment and suggests that the framing of evaluative questions significantly shapes participant perceptions of skill importance.

The convergence between quantitative and qualitative methodologies provides robust evidence for the centrality of most transversal skills. Interpersonal communication and project planning skills, which demonstrated the most pronounced effects in the quantitative assessment, maintain their prominence in the individual qualitative evaluations, with documentation, project management, team management, meeting management, communication and collaboration as the top six mentioned competencies in the qualitative findings. We should note that the portofolio was not the only assessment activity, but rather a complement to project report, that included. risk management. Therefore, the analysis of the portfolio may not have captured all of the transversal skills addressed in the assessment activities. However, risk analysis, while exhibiting a moderate effect size in the quantitative analysis, received lower ratings in the qualitative component (mentioned in only one third of the portfolios). We should note that the portfolio was not the only assessment activity but rather completed a project report. Risk management was included in the project report. Therefore, the analysis of the the portfolio may not have captured all of the transversal skills addressed in the assessment activities. suggesting potential discrepancies in perceived versus stated importance as measured by two types of assessment tools. These complementary findings strengthen the validity of the identified competency hierarchy, while revealing the nuanced nature of skill valuation among participants.

Overall, our results suggest that the training portfolio model may be a pedagogically productive tool, where students' attention could be focused on the desirable learning outcomes, including transversal skills. While the described portfolio model shares with LIPS (Wetterö et al., 2006; Rosqvist et al., 2008) an emphasis on reflecting upon collaboration and project management processes, it additionally encourages students to reflect on the emotional dimensions of teamwork and on how learning itself takes place throughout the project process. The intention was not only to support the development of transversal skills, but also to foster greater student awareness and regulation of their own cognitive and emotional processes during project-based learning.

Limitations

While this case study combines a rich tapestry of data, we are aware that there are elements missing, such as observations of classroom teaching, documents and communication on the learning platform, slides shared in mini-lectures and student-teacher exchanges during the coaching sessions. In this case there is no "control" group against which our class group is compared. Since this is a real-world class, it would have been ethically difficult to set up such a control (as it would have involved giving a pedagogy which we believed to be less beneficial to students whose grades had potentially career-altering impact). And, we already know from prior studies that where students' attention is not directed to transversal skills, their self-efficacy beliefs do not change significantly during project based learning

(Picard et al., 2021). While it seemed reasonable for us to document the portfolio in this way, a future research type study may use a more randomized control experimental design.

Given the semester-long project work that happens in parallel with other courses the students take in the spring semester of their master's studies, we cannot completely exclude that the effects we documented are not due to other factors. Nonetheless, given that the students come from different study programs, we can assume that they follow very different courses and hence could appropriate the effects to the use of the training portfolio in this project-based course. Finally, the triangulation between the course documents (intended curriculum) and the quantitative (increase in self-efficacy beliefs) and qualitative findings (self-reported learning transversal skills) support the claim that the structured training portfolio supports transversal skills development.

Conclusion and Further Contributions

This study makes a dual contribution: one to the literature on engineering education and the other to pedagogical practice. It provides empirical evidence on a specific scaffolding instrument—the training portfolio—used as a tool for operationalizing the goal-framing and assessment principles that other curriculum frameworks have already established (CDIO Initiative, 2022a; 2022b; Crawley et al., 2014). While comprehensive taxonomies of transversal skills and normative standards for their integration and assessment exist, empirical evidence on the specific instruments that make these standards actionable in master's-level project courses remains limited. This study addresses that gap.

Methodologically, the study provides a replicable model for dual-goal framing in PBL: by requiring students to articulate both product goals and process/competence goals, and to document evidence of competence development across the project lifecycle, the training portfolio transforms the project lifecycle structure from a curriculum organizing principle into a student-facing reflective tool. This operationalization of evidence-based assessment logic into a formative portfolio instrument is a novel contribution to both PBL implementation research and the broader engineering education literature.

For practice, the study shows a convincing example for engineering educators and program designers with a validated, transferable model for redirecting student attention from artifact completion to process-oriented learning. We have endeavored in the paper and in the supporting material to provide sufficient detail to allow others to adapt or adopt the model. The training portfolio approach is designed to be implementable within existing project-based curricula without requiring large program redesign, making it particularly relevant for institutions seeking to strengthen transversal skill development within established course structures. By grounding the portfolio design in an explicit competency taxonomy, the model also provides a common language for faculty, students, and accreditation bodies to discuss, assess, and report on transversal skill development - addressing a persistent challenge in engineering education quality assurance.

Declaration of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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