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ORIGINAL ARTICLE

Future-ready skills development through Experiential Learning: perceptions from students working in multidisciplinary teams

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ABSTRACT

This paper addresses the learning outcomes and student perceptions of the Aalto University Product Development Project course (PdP), which promotes experiential learning and where multidisciplinary master student teams work on industry-based projects. These outcomes were collected through a questionnaire filled by students voluntarily, which focussed on what were the main competencies, where they were acquired and what was the core learning. The results highlight the significance of interpersonal skills, which formed the most notable category reported by students, and were perceived as critical for project success. Furthermore, the study highlights the importance of the multifaceted role that prototyping plays in communication and sense-making.

Keywords: Experiential Learning; product development; multidisciplinary education; interpersonal skills.

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INTRODUCTION

The future of work presents educators with a challenge: given the rapid rate of technological development, the fast-changing pace of social and environmental trends, and rapidly changing global socioeconomic positions, how does higher education empower graduates to succeed in the workplace? This question responds to the need to include 'future-ready' skills in learning experiences, equipping students to navigate future risks, complexities and opportunities (Holloway et al., 2019). Students must develop various personal and professional skills to succeed in the industry. Organisations expect new professionals to contribute not only to disciplinary knowledge, but also through communication and collaboration. This has highlighted the need for soft skills development during education and the ability to integrate different knowledge areas (Stewart et al., 2016; Nicola, et al., 2018; Succi et al., 2020).

The development of collaboration, communication, creativity and other noted ‘soft skills’ has been difficult to achieve within traditional formal education paradigms that place the instructor central to the learning environment (Fisher et al., 2014). More learner and learning-centred paradigms have addressed some of these challenges (Vogler et al., 2018). These approaches include problem and project-based learning, grounded in experiential learning, traditionally offered in a physical environment.

Claxton, Costa and Kallick (2016) note that curiosity “also involves a deeper pleasure in making discoveries and an openness to novelty and challenge. To develop such inclinations, students need ongoing opportunities, encouragement, and guidance in various contexts” (p. 61). The link to curiosity is specifically relevant to design and to disciplines that promote creative problem-solving as part of professional core capabilities.

Many universities have defined objectives to support the development of industry focussed core capabilities (Aliu et al., 2021). Critical skills include oral and written communication, problem-solving and the ability to collaborate (Rios et al., 2020). The same skills were considered essential by STEM graduates, along with creativity, intercultural communication and entrepreneurship (Lavi et al., 2021). This leaves the question of how to assess learner achievements and skill development in the context of Experiential learning or problem-based learning (PBL). Constructive alignment is often presented as a notion that expresses the extent to which the training programs' intended goals align with the overt and unexpected goals of the assessments (Biggs., 1996). However, Vleuten and Schuwirth (2019) assert that, if there is a discrepancy between the two, the evaluation impact frequently precedes the intended learning strategy. To properly comprehend this discrepancy, one should evaluate significant frictions surrounding evaluation in a PBL environment. Hence, PBL is believed to encourage the development of skills other than just knowledge, such as teamwork and communication, which are more domain-independent. Some initiatives to develop more adequate ways of assessment have been made in response to the apparent tension between what was normally assessed and what was intended to achieve with PBL educational approaches. Consequently, this research explores what students from a collaborative multidisciplinary course perceive as the competencies required to complete a project successfully and what their core learnings were during it. Since experiential learning-based courses tend to cultivate more work-life skills, this study collects student perceptions to understand the impact of experiential and problem-based courses, shedding light on what skills and attitudes are fostered. The study utilised two research questions:

(i) *What skills do students consider important for successful project completion within the context of experiential learning?*

(ii) *What do students consider to be their core learnings from successful project completion in the context of experiential learning?*

The findings of this study present the students' skills development from a single course and are not intended for extrapolation into generalised understandings. Instead, they represent the first sample from a more extensive collective case study, exploring the phenomena against the backdrop of a global pandemic.

THEORETICAL BACKGROUND

Experiences incorporating multicultural and diverse conditions provide a unique space for learning, positioned at the border of disciplinary, cultural and social groups (Klaassen, 2018). There, learning occurs through experiential practice, emphasising experiences, and seeing education as a social process (Tuulos et al., 2016). Experiential learning, also known as learning by doing (Dewey et al., 1915, cited in Gentry, 1990) or experience-based learning (Wolfe et al., 1975, cited in Gentry, 1990), is defined as the act of learning from experiences. It involves a high level of engagement from participants (Lewis et al., 1994; Gentry, 1990), viewing "learners as active participants," acknowledging previous learnings as foundations for further learning, promoting "interaction with others, leading to greater understanding" (Hedin, 2010, p.109). Experiential learning theory is defined as the process whereby knowledge is created through experience transformation (Kolb, 1984). Knowledge results from the combination of grasping and transforming experience. To successfully implement those methods, the learner must go through four stages: 1) concrete experience, 2) reflective observation, 3) abstract conceptualisation, and 4) active experimentation. Therefore, experiential learning relies on the provision of an experience and reflection upon the experience (Fowler, 2008), the former being dependent on factors such as the degree of involvement of the student, subject's relevance, depth of learning achieved, proximity to real-life environments (Fowler, 2008; Mason et al., 2013; Cooper et al., 2004).

Team-based learning can be more engaging (Balan et al., 2012), and multicultural teams can strengthen global competencies (Oda et al., 2017). Bailey et al. have also indicated the advantages of cognitive diversity within team-based learning activities (2021). The benefits of multidisciplinary knowledge are not always guaranteed (Garcia-Rodriguez et al., 2012; Lüthje et al., 2006 as cited in Bailey et al., 2021) and thus, to facilitate results, developing a shared sense of purpose is deemed essential (Kayes et al., 2005). Team members need to feel included, and a sense of trust and psychological safety should also be provided (Kayes et al., 2005).

Moreover, Aronson & Patnoe (2010) present effective teams through the metaphor of a Jigsaw model whereby members should view themselves as different pieces of the puzzle, fitting together (as cited in Bailey et al., 2021). Thus, student teams within experiential entrepreneurial education should be multidisciplinary, motivated, and must be supported by facilitators and educators in a pull-based learning model. Student interactions can be a key success factor of experiential entrepreneurial education methods if the roles of managing, using, and creating new knowledge and information can be successfully organised (García- Rodríguez et al., 2012).

Eppinger and Kressy (2002) indicated student empowerment, student appreciation for other disciplines, team working skills, communicational and project management skills as lessons learned from their 10 years of interdisciplinary product development courses at MIT[1] and RISD[2]. Wiesche et al. (2018) discuss the importance of establishing interdisciplinary teams for design-oriented project courses to foster and support creativity and novelty. Moreover, interdisciplinary teams also better simulate real-world environments (Wiesche et al., 2018).

Lastly, prototyping, a crucial component of design-oriented projects, was defined as the means for the teams to not only refine and iterate their concepts, but also to communicate ideas within their teams and receive feedback (Lande & Leifer, 2009). Prototyping can be seen, for the student teams, as a valuable starting point towards grounding and directing the project, improving their working efficiency, and becoming more knowledgeable about the topic at hand (Lande & Leifer, 2009). Olsen (2015) also indicates that prototyping supports the thinking process of innovators as it allows them to build "simple models or drawing sketches before knowing the answer" to the questions at hand (p. 183).

METHODS AND DATA

This study examines the students' self-reported skills and key learnings acquired through multidisciplinary, project-based and experiential learning at the PdP (Product development Project) course at Aalto University. A questionnaire completed by 33 students from the 2021-

[1] https://www.mit.edu/

[2] https://www.risd.edu/

2022 PdP course captured skills students believe they developed during the course and the core learnings attained, employing problem-based (PBL), integrative and experiential learning. Therefore, in this study, *learnings* are defined as the measurable aptitudes acquired as a result of participation in the PdP course. Whereas *skills* represent one's ability which might spring from previous knowledge and practice. The study's research instrument allowed students to share what they believed the critical skills necessary for a successful course completion were and where those were acquired.

Integrative learning is facilitated through multidisciplinary student teams' engagement as they explore and aim to understand knowledge instead of 'make sense of knowledge' (Ashby et al., 2019). The PdP course allows students to explore previously acquired methods and knowledge in practice, fostering new learning beyond their study fields. Due to the Covid pandemic, during the 2021-2022 academic programme at Aalto restrictions were being lifted, but still influenced the educational environment, leading to the adoption of online or hybrid options, where accessible content and learning experiences for isolated students were required. Thus the questionnaire was made available digitally and physically. The questionnaire included quantitative and qualitative questions and focused on reflecting on the most valuable skills used by students for the project's success and identifying their core learnings after course completion. It posed three core questions:

What were the main skills that made your PdP student project successful?
Where did you acquire the key skills for your project?
What was the core learning?

The first and second questions were addressed by determining numerical values of perceived skills to establish the most frequently noted. The questionnaire included initial pre-listed skills from all subject areas represented in PdP groups, with multiple spaces to add individual responses. The subject areas represent the most prevalent among registered participants, namely: Design, Mechanical Engineering, Electrical Engineering, Information Technology and Business. The fields were cross-referenced with students' undergraduate fields and interviews with the primary lecturing staff and faculty within the PdP program. Active lecturing staff reflected on student deliverables (from both past projects and the 2022 cohort) and suggested the initial skill list associated with each of the various fields. To ensure students could capture additional skills, each field included open spaces to capture individual perceptions. The set of soft skills included in the questionnaire was adapted from those identified by Lippman, Ryberg, Carney and Moore (2015) for youth workforce success: social skills, higher-order thinking, self-control, communication skills, teamwork, positive attitude, and responsibility.

In the third question, the key areas of learning that students indicated the course facilitated were captured qualitatively in an open-question format. These observations provided additional insights and contextual descriptions related to the skills indicated. The questionnaire was administered after the final course evaluation, ensuring voluntary participation. In total, 33 students participated in this study, representing 60% of all course participants[3]. Table 1 presents the team role and disciplines of the participants.

Table 1. Background information of the respondents.

Background Information	Questionnaire Respondents	Total (n)	Total (%)
Total number of respondents	PdP students	33	100%
Role in the team	Team member	29	88%
	Project manager	4	12%
Discipline	Design	4	12 %
	Mechanical Engineering	15	45 %
	Electrical Engineering	4	12 %
	Information Technology	2	6 %
	Business	3	9 %
	Other	5	15 %

Table 2. Student Response coding example

Student response	Assigned open codes (focussed code)	Emerging themes
"Coming from different culture, most of the time, I just studied theoretically, here beside building a physical device, I learnt about user testing, prototyping, working with very different students from different backgrounds and set a milestone" *(Mechanical Engineering Student)*	Multidisciplinary teamwork Multicultural teamwork	Interpersonal Skills (IS)
	Product development process	Product Development (PD)
	Management and organisation	Project Management (PM)

[3] Only students from Aalto University are considered in this study.

To allow students the opportunity to discuss their perceived core learning in their own words, the third question was open. Students' written responses were analysed and coded. Table 2 shows an example of the coding allocation. The open codes were reviewed to establish relationships and form focused code groups. Once all codes were reviewed, the emerging learning themes were established.

RESULTS

The questionnaire respondents identified the skills most critical for their success correlated to personal, interpersonal and team development and engagement. The skills (n=43) students selected from a pre-list were organised in a hierarchical order in Table 3. These responses show the main competencies students believed were required during the PdP course, and where they acquired them. n=5 students reported less than 20 listed skills, n=14 between 20 and 30 skills, and n=14 more than 30 skills. Most noted ten skills were the ability to communicate efficiently with team members from different backgrounds (73%, n=24 of the respondents) and working in a collaborative way that recognises different opinions (61%, n=20). The ability to resolve conflict was selected by more than half (55%, n=18) of the participants. Additional skills include managing team time effectively (61%, n=20) and communicating your challenges effectively (67%, n=22). The experimental nature of Product development contributed to creative problem-solving skills (48%, n=16) and to the personal ability to adapt to unexpected challenges (67%, n=22). The skills relating to prototyping include prototyping as a method to test ideas (70%, n=23), a form of communication (58%, n=19), and a way of thinking (52%, n=17). The relevant presence of prototyping related skills highlights that prototypes can often be useful and necessary tools for consolidating design knowledge (Menold et al., 2020), and promoting mental models or ways of thinking. Furthermore, prototypes can also be perceived as communication tools and embodiments of design thought (Lauff et al., 2019). Our study raises awareness of the role of prototyping in experiential learning and product development, placing 'making' in the centre of discovery, communication with others, and a better understanding of the challenge addressed.

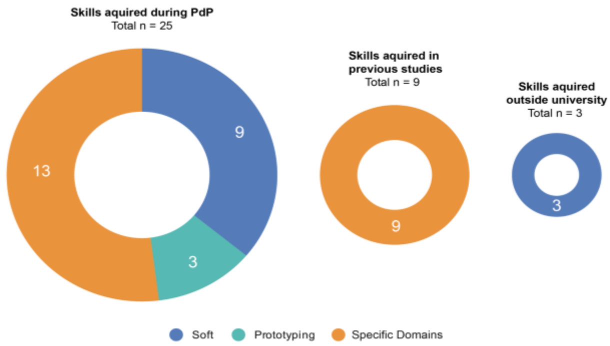

Fig. 1. Assessment of where skills were acquired

Table 3. Respondents' perceived skills and where those were acquired.[4]

Perceived skills in PdP (n=43)	Acquired during PdP	Acquired in previous studies	Acquired outside university
1. Communicate efficiently with team members from different backgrounds	73%	33%	15%
2.Quick Prototyping as a form of Testing	70%	15%	12%
3. Good adaptability towards unexpected challenges	67%	24%	39%
4. Communicate your challenge effectively	67%	27%	21%
5. Effective team time management	61%	24%	21%
6. Work in a collaborative way that recognises different opinions	61%	27%	36%
7. Prototyping as a form of Communication	58%	9%	45%
8. Resolve Conflict	55%	18%	27%
9. Thinking by Making	52%	15%	21%
10. Creative Problem Solving	48%	21%	42%
11. Effectively manage ambiguity	48%	18%	15%

[4] Full table available in supplementary materials.

Perceived skills in PdP (n=43)	Acquired during PdP	Acquired in previous studies	Acquired outside university
12. Listen carefully and actively to the ideas of others	45%	36%	36%
13. Designing & Electrical Device Systems	42%	12%	6%
14. User Experience Research UX	39%	42%	9%
15. Design Thinking - Concept & Ideation	39%	58%	27%

Furthermore, the questionnaire results, presented in Figure 1, highlight that 58% (n=25) of the skills were acquired during the PdP course, 21% (n=9) in previous studies, and 7% (n=3) outside the university[5]. All skills acquired in earlier studies were from specific academic domains (Design, Mechanical Engineering and Business). In contrast, all skills acquired outside the university are soft or interpersonal. Whereas skills acquired during the PdP course combine specific domains, prototyping, soft and interpersonal.

The final question asked students to reflect on what was their core learning during the course as an open question. The responses reiterated the perceived development of interpersonal skills and the integration of disciplinary skills within the broader context of product development. The emerging core learnings noted, based on the responses, are indicated in Figure. 2. In total, the number of reported learning elements was 72, as some students indicated more than one core learning in their response. Figure 2 illustrates a thematic overview and analysis of the core learnings noted by the questionnaire respondents. Five main themes were identified: Interpersonal Skills (IS), Attitudes (A), Domain specific skills (DSS), Product Development (PD) and Project Management (PM). It should be noted that the learning themes introduced are an interconnected web of skills and knowledge, with IS for example, influencing A and PD. PD supports PM, while simultaneously influencing DSS. Figure 2 also enables an initial overview of the core learning themes by identifying them in a shared language of visual elements, contributing to a unified and tangible understanding of the skills and knowledge.

Responses noted the need for optimism and persistence as an attitudinal skill (A) developed. Examples of student responses below highlight the mentioned attitudes:

> “Don't wait for others to do your job, just do it.” (Mechanical Engineering Student)

> “It is very important to maintain a positive attitude towards the difficulties and not give up” (Mechanical Engineering Student)

Furthermore, responses perceived an integrated view of product development (PD), and the skills associated with the process (n=11), including: problem-solving, resolving product implementation challenges and prototyping as a form of learning through making and thinking through making. The following response stresses the span of different skills and learnings related to the complex process of Product Development and the resilience to resolve unexpected challenges.

> “Being able to adapt to different challenges is complicated, but has to be done at some point. Sometimes it is more valuable to get things going and learn on the process than trying to come up with a perfect plan” (Mechanical Engineering Student)

Project management (PM n=13), and associated personal and project management skills were also noted. Intrapersonal skills (IS) identified (n=40) included self-awareness and self-knowledge, adaptability, creative thinking, decision-making, cultural awareness, communication and teamwork. These formed the largest group of perceived learning areas. The examples below shed light on the value of adaptability, self and cultural awareness.

> “The main learning I got from PdP was to adapt and survive. Theorising and planning is very beautiful and a great tool, but reality rarely goes according to plan. And I honestly felt that I grew up as a professional enormously thanks to that particular skill. Now I feel way less afraid to go into a company and being tasked to tackle some problem I've never faced before. No matter what it is, I know I can adapt, survive and come up with a sort of solution.” (Electronics and Nanotechnology Student)

> “Listen to what others do not say. Finnish culture is very different from mine, be patient with undecided insecure people” (Mechanical Engineering Student)

Teamwork was often noted (n=19) as a developed skill and includes building trust, conflict resolution, fostering team relationships and working in multicultural and multidisciplinary teams. The response below emphasises why multidisciplinary and multicultural experiences promote key learnings.

> “...something that PDP taught me (that my own parents nor the academia or work life has ever taught), is how to handle situations in which the viewpoints of

[5] 5 skills from specific domains were acquired both in PdP and previous studies and 1 in all three environments. These 6 skills are not included in Figure 1.

different people are so radically different that neither can ever fully understand what the other person is thinking and why they are thinking so differently. These situations aren't easy, because they can easily cause conflict, but I think that even though we had our conflicts, we learned to handle the different viewpoints and learned to work as a team." (Economics Student)

Intriguingly, only a handful of students perceived domain-specific disciplinary knowledge skills (DSS) developed (n=5) as core learning during the course

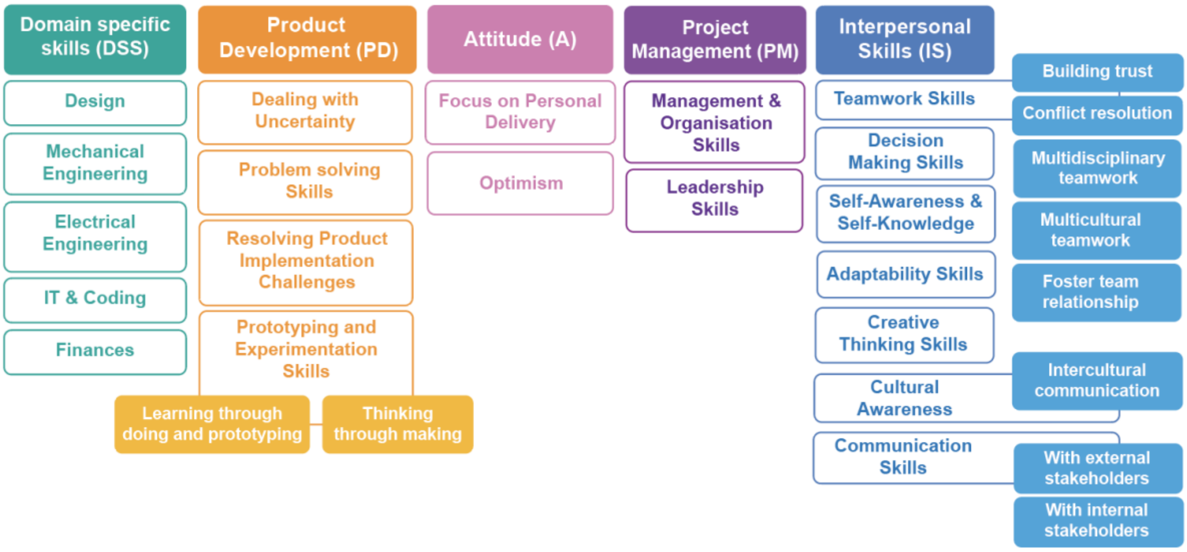

Fig. 2. Core learning theme

DISCUSSION

The PDP course often represents students' first end-to-end experiential project learning opportunity, where proximity to real-life environments is critical. Previous research in the context of the PdP course (Rautavaara et al., 2014) considered the programme a good tool for developing communication and hands-on doing, in comparison with standard lecture-based courses. In the experiential context of PdP, educators aim to create situations mimicking real-life contexts, as in entrepreneurial education. Results highlight the significance of interpersonal skills during experiential learning, including self-awareness and self-knowledge, adaptability, cultural awareness, communication and teamwork. These formed the most significant category reported, students perceiving them as required for project success.

Students reported that interpersonal and attitudinal skills supported better engagement with product development processes and project management. Efficient communication within multidisciplinary teams was the most prominent skill students believed they developed during the course. Multidisciplinary teams can further support students' learning outcomes, providing better experiences and supporting diverging and converging processes within Kolb's learning cycle.

As communicative, interpersonal, and entrepreneurial skills become more critical for graduates entering the job market, providing an opportunity to learn them at university becomes imperative. Based on questionnaire responses, competencies acquired during the PdP course combine different academic domains, prototyping, soft and interpersonal skills emulating 'future-ready' skills. Therefore it can be argued that experiential learning supports the development of these aforementioned skills through the acknowledgement that interactions with others lead to greater understanding (Hedin, 2010), depth of learning achieved (Cooper et al., 2003), and a higher level of involvement from the participants themselves (Lewis et al., 1994).

Our findings also align with the views of Wiesche et al. (2018), whereby the provision of interdisciplinary teams better mimic real-life environments for the students. Previous studies reported the perceptions of course alumni (who graduated between 1999 and 2016). Findings from these 33 interviews and 239 surveys, conducted as part of the study, showed that socio-behavioural interpersonal skills contributed most to their careers; including communication, teamwork, navigating multidisciplinary environments and attitudes (Mikkonen et al., 2018). Our findings also closely resemble the learnings shown by Eppinger & Kressy (2002) within interdisciplinary product development courses.

This study also revealed that prototyping was seen as a physical form of communication, extending it into a 'makerspace' where students explain, decide and negotiate their understanding of a given context in a physical form. Based on this, one can state that our findings align with the views of Olsen (2015), who viewed prototyping as a tool that can help innovators to think. In a similar fashion, our findings indicated students viewed prototyping not purely as the skill to design, but also as a way for communicating and building their ideas from, and for supporting their thought processes. The prevalence of prototyping as a skill noted by students offers a unique insight into the experiences of the student cohort who completed the course during the global pandemic. Furthermore, it identifies the student's course perceptions very close to the completion of the course, whereas Mikkonen (2018)'s respondents had completed the course at least 1.5 years before and were reflecting on working life and memorable learning experiences based on the course.

CONCLUSION

In this study, students identified prototyping as an efficient communication tool within their project-based groups and an artefact representing collective decision-making. This finding highlights the multifaceted role that prototypes can play in sense and meaning-making: they are not only vehicles to communicate team ideas to stakeholders, but also present an opportunity to negotiate meaning and communicate through making, *within* the team. Prototypes represent a crucial design artefact, bridging internal mental models with external representations among individuals (Bucciarelli, 2002, cited in Nelson et al., 2020). The act of prototyping was also seen as a means to "communicate ideas, receive feedback" (Lande & Leifer, 2009: p. 1).

Future research should analyse additional experiential courses to form an extensive collective case study, exploring the phenomena and the learning outcomes. It would also be prudent to conduct a follow-up study that includes a control group of students to allow for comparative analysis. Comparative studies could also be conducted across academic years or within other project-based courses. Furthermore, the empirical results reported herein should be considered in light of some limitations due to the questionnaire format. The questionnaire uses pre-listed skills for the first and second questions, which might influence students' responses and bias the answers to the third open question. Therefore, future development of research instruments should account for this limitation, and prospective studies should examine the skills utilised and learnings acquired separately.

Examining these findings from the standpoint of course design and potential curricula is equally pertinent. In this study, students identified interpersonal, managerial, and attitudinal abilities as the most important elements or prerequisites for project success and future readiness. Therefore, experiential learning is a core method for teaching and enhancing such attitudes, emphasising student-led learning and working through real-world problems. As these courses are becoming more prevalent at academic institutions, clearly defining the experiential learning outcomes in advance is essential. However, we are still in the midst of understanding how to evaluate student accomplishments, outcomes and skill development in the context of experiential learning and problem-based learning (PBL). Therefore, this study sheds light on how to assess experiential and problem-based learning from a more holistic view, where assessment not only drives learning but learning drives assessment, based on student reflections, skills recognition and identified core learnings.

SUPPLEMENTARY MATERIALS

To complement this manuscript, the authors have added an additional full data table relative to the respondents' key perceived skills in the context of the PdP course and where those skills were acquired. This supplementary table expands Table 3 and sheds light on the total (n=43) number of skills identified in hierarchical order by the questionnaire respondents. It might drive future research that is out of this study's scope.

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