The "Sweet Spot" for Reflection in Problem-oriented Education: Insights From Phenomenographic Action-research

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ABSTRACT

This paper examines the impact of a structured, multi-dimensional reflection track of a 16-week pilot programme in experimental pedagogics (XP) in The Netherlands. XP is an elective undergraduate programme in which students investigate socially relevant educational problems in local communities and design educational interventions to address these issues through problem-oriented project work (PPL). To accompany the learning journey, students follow a reflection track structured with workshops, learning diaries, and articulated learning essays, that cover cognitive, phenomenological, relational, social, and global dimensions of reflection. The design of the track was informed by an interdisciplinary reflection framework combining inputs from cognitive and critical paradigms. To evaluate and improve the impact of this novel approach to reflection in problem-oriented education, the authors undertook an Education Action Research (EAR) process with the 17 participating students. The evaluation phase of the EAR was conducted using a phenomenographic design to draw out qualitative variations in conceptions of reflection among students who participated in the pilot. Focusing on variations of conceptions allowed the teachers-as-action-researchers to gain a fine-grained understanding of reflection within the XP problem-oriented setting. The findings reveal an outcome space comprising seven increasingly complex reflection categories. A phenomenographic analysis of the categories led us to conclude that

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there exists a reflection "sweet spot" inside which there is growth in reflection breadth and depth. Outside the sweet spot, students either do not reflect at all, or become so entangled in reflection that an infinite reflection regress appears to derail learning. We conclude by discussing the contributions of these findings to strengthening critical, socially relevant reflection in problem-oriented project work in the context of current global crises, focusing on the role of supervisors in fostering productive reflection.

Keywords: Problem-oriented project work, reflection, action research, phenomenography, experimental pedagogics

INTRODUCTION

Reflection skills have been an important objective of problem-oriented learning in higher education since the earliest days of these pedagogies (Servant, 2016). Whether in problem-based learning (PBL) or in problem-oriented project work (PPL), in all fields ranging from medical and engineering education to social sciences and humanities, educators report on problem-oriented learning's capacity to get students to introspect on their learning trajectories (e.g. Gibbons, 2018; Hmelo-Silver, 2004; Seibert, 2021).

For clarity's sake, we use problem-oriented learning as an umbrella term covering different pedagogies that share common principles of student-centred learning, constructivist learning principles, and where the learning process begins with an ill-defined problem (Servant, 2016). Within that umbrella, different expressions of problem-oriented learning appear with markedly different implementations. Problem-based learning (PBL) refers to a method of learning in which students tackle (usually written) problems designed by content-experts, in sessions guided by a tutor. Although students are encouraged to form learning objectives, course learning objectives and literature are contained within a tutor manual that serves as a reference (Barrows & Tamblyn, 1980; Moust et al, 2021). Problem-oriented project work (PPL) refers to a method of learning in which students work in group of 3-7 on a larger, real-world problem, which they investigate over an entire semester. Students define the problem themselves, guided by a project supervisor (Andersen & Heilesen, 2015; Kolmos et al., 2004).

The scope of reflection within problem-oriented learning has generally focused on a cognitive interpretation, with the ideas of Dewey, Kolb, Schön, Piaget and Vygotsky as prominent sources of inspiration (De Graaff & Kolmos, 2003). This can be explained, firstly, by the strong constructivist roots of problem-oriented learning, in both its PBL and PPL iterations (Schmidt, 1993; Servant, 2016). Secondly, the majority of renowned

reflection models in education offer variations on the cognitive paradigm, with a strong focus on problem-solving (Rogers, 2001).

In the early days of PPL in Germany and Denmark, reflection was also understood through the critical lens of C. Wright Mills' "sociological imagination", which placed individual reflection within a broader historical and sociological context. Mills' work, as interpreted by the German critical pedagogue Oskar Negt (1974), was instrumental to the Danish PPL founders' understanding of project work (Hansen, 1997). A psychoanalytic and existential view of learning was implicit in the assumptions underlying critical reflection at that time. However, as PPL moved away from its critical roots from the 1980s onwards, cognitive interpretations of reflection superseded other paradigms (Servant, 2016).

Critical reflection is undergoing a revival in the light of the enormous challenges the world faces today (e.g. Biesta, 2020; Dahl & Kennedy McFoy, 2022; Giroux, 2018). Institutions that had previously moved away from critical learning approaches under political pressure to compete in the global marketplace at the height of the neoliberal era (1991-2008) are now attempting to revive them (Andersen & Heilesen, 2015). Following this revival of socially conscious education, we developed an extra-curricular, project-based (PPL) educational programme in Experimental Pedagogics in Spring 2021. Twenty students from different social sciences undergraduate programmes enrolled for this 16-week course comprising three tracks. First, a project track in which teams of students researched and addressed a real-world educational problem by designing an educational intervention which they targeted at their project problem. An education track provided students with the tools and knowledge they needed to design their intervention. The third track offered a multi-dimensional, structured approach to reflection, in which four dimensions of reflection were explored: cognitive, phenomenological, relational, societal (and global).

The teaching team for Experimental Pedagogics ran an Educational Action Research (EAR) process alongside the educational activities to inform and improve the educational practices (Mertler, 2019). EAR is embedded in the critical educational tradition as a way to include educational stakeholders in the educational design and improvement process. It was first described as an emancipatory educational tool in Freire's *Pedagogy of the Oppressed* (1968), and has since become a mainstay of critical pedagogy practices (Miskovic & Hoop, 2006). As part of the EAR process, we investigated the impact of the Experimental Pedagogics programme on students' conceptions of reflection.

Research Questions:
1. *After participating in a 16-week Reflection Track as part of the course Experimental Pedagogics, what are the qualitatively different ways in which*

students understand and practice reflection in a problem-oriented learning environment?

2. *What practical lessons can the problem-oriented learning community draw from the insights gained from this?*

3. *How does this insight contribute to steering the action-research cycle for the course Experimental Pedagogics?*

A unique feature of our action-research approach was the integration of a phenomenographic research design (Cherry, 2005; Marton, 1986) in the evaluation phase of the action research. This means that instead of focusing on common themes, we uncovered variations emerging from the student experience of reflection. We chose this approach to map out possible different experience categories that our unique approach to teaching reflection could trigger. With such a map, we hoped to understand how different conceptions align (or misalign) with our programme objectives, what educational outcomes they trigger, and what pathways students take to reach their conception. This paper will review the literature on problem-oriented learning and reflection, present the EAR methodology enhanced with a phenomenographic evaluation design, and discuss findings on reflection and problem-oriented education.

LITERATURE REVIEW

Although there is abundant literature on reflection in the educational field, there is no consensus on a clear definition and approach to the concept (Ottesen, 2007). The first mentions of reflection in teaching stem from John Dewey's experiential learning philosophy in the 1930s (Liu, 2015). In the 1980s, these intuitions were further developed by Donald Schön, focusing on the link between action and reflection (Ash & Clayton, 2009; Liu, 2015; Rogers, 2001). In the decades that followed, reflection solidified itself as a crucial tool in teaching (Liu, 2015). Schön's work was used to develop increasingly sophisticated models (Ottesen, 2007; Rogers, 2001).

Reflection scholars seem to agree that the reflective process is at least in part a cognitive endeavour (e.g. Kuk & Holst, 2018; Ottesen, 2007; Rogers, 2001). This does not mean that reflection is a mere act of describing, summarising or repeating learning content. Reflection is defined as a process of carefully examining one's personal beliefs and individual behaviours and a willingness to adapt them if they are not in line with the desired outcomes. As this process can be challenging, the best place to start is often bringing awareness to the obstacles that may interfere with these aims (Gay & Kirkland, 2003, Ottesen, 2007). When implemented correctly, the process leads to a richer understanding from which the learner is able to consider and adapt to the insights acquired in the process.

Reflection has always been at least tacitly present in the practice of problem-oriented education (Servant, 2016), within which different paradigmatic understandings of reflection have emerged.

Cognitive Reflection

The cognitive paradigm frames reflection as a means to reinforce the learning process, and create new learning strategies. For example, Ash and Clayton (2009) see reflection as an essential step of the learning process: to solidify new knowledge, we must first take a step back to reflect on the new information. When this is not done, learning can be superficial and unpredictable. Similarly, Hmelo-Silver (2004) stresses the importance of reflection in stimulating PBL student's ability to combine new academic information with prior experience. This approach to reflection in PBL, which mostly takes the form of auto-and-peer-feedback, promotes the learner's ability to self-regulate and rectify the shortcomings in their learning process (e.g. Hmelo-Silver, 2004, p.247; Savery & Duffy, 1994, p.6; Hendry, Frommer & Walker, 1999). While these approaches suggest promising outcomes in learning, the benefits of reflection are not expected to transcend the classroom. The value of reflection in these conceptions is purely performance-based, in the sense that its function is to improve student performance measured in quantifiable results and course grades. Servant-Miklos and Kolmos (2022) identified the negative impact of focusing exclusively on cognitive reflection in PPL students. They found that when personal motives, social dynamics and societal factors are excluded from reflection practices, students can develop unproductive conceptions of problem-oriented work. For example, neurodiverse students experienced problem-oriented work as hostile social arenas. The lack of psychological safety within the project group impeded learning and led students to attribute their distressing experiences to the pedagogical format. They were unable to reflect on group dynamics and how to improve them.

Critical Reflection

The term "critical reflection" has been used in problem-oriented learning literature to mean reflection that leads to changing one's teaching and learning practice (e.g. Du et al., 2020). In a similar way, the term "critical thinking skills" is often used to refer to thinking that challenges current educational practices and contents. However, in this paper, "critical" refers to a social-transformative educational paradigm (Servant-Miklos & Noordegraaf, 2021), in which reflection is conscious of socio-economic disparities and wider historical processes that govern social change.

Critical theory contributed to early discussions on reflection in problem-oriented education in the PPL approach (Andersen & Heilesen, 2015; Illeris, 1974; Servant, 2016). Illeris' (1974) seminal work on the subject built on Negt's historical materialist and psychoanalytic critical pedagogy (Negt, 1974). Negt translated Mills' sociological imagination into experience-based emancipatory project work, following the concept of

critical exemplarity (Servant-Miklos & Guerra, 2019). Although the critical approach was side-lined in PBL and PPL literature and practice in favour of cognitive reflection in the 1980s, there has been renewed interest in last decade. For instance, Noordegraaf et al. (2020) critiqued the dominance of the cognitive paradigm in PBL, suggesting that it cuts students off from the world at a time of heightened global crises. Servant-Miklos and Kolmos (2022) came to similar conclusions regarding PPL. They also found that an exclusive focus on cognitive reflection can be harmful to social dynamics in project groups, impacting students' identity formation processes by leading them to develop more individualistic professional identities.

Borrowing from Bourdieu's sociology, psychoanalysis and existential phenomenology, Feilberg (2014, 2016) argued that the formation of a professional and scientific *habitus* in project work requires reflective practice surrounding social and emotional processes in the group work, uncovering internal psychological processes such as (unconscious) motives and drives, and interpersonal psychological processes such as group dynamics. He also argued that supervisors play an important role in guiding productive student self-reflection of intrapersonal psychological processes in project work (Feilberg, 2016). In doing so, he developed the existential-phenomenological and psychoanalytic underpinnings of critical reflection but stopped short of exploring its implications for a learning in a world destabilised by crises. Taking this added step, Servant-Miklos and Noordzij (2021) noted the importance of integrating a praxis of action and reflection in problem-oriented sustainability education to steer students away from unproductive strategies of denial, bargaining and despair.

Most reflection research and practice follows either one or the other reflection paradigm. This paper offers a reconciliation of cognitive and critical approaches, presenting the impact of a multi-dimensional reflection programme in the Experimental Pedagogics programme in The Netherlands.

METHODOLOGY

Reflecting on Educational Action Research with Phenomenography
This paper presents the evaluation phase of EAR cycle in which we collected and analysed data using a phenomenographic design. We will briefly present EAR, describe the initial phases of our EAR cycle, and explain how we designed our evaluation phase with phenomenography.

Educational Action Research. Educational Action Research is a participatory, cyclical research approach, where practitioner-researchers aim to improve their own educational practices (Mertler, 2019; Olin et al, 2016). An EAR cycle typically comprises an

investigation, action, and an evaluation phase that informs the next cycle by suggesting improvements to practice (McAteer, 2013; McNiff & Whitehead, 2006). What makes our research fall under EAR rather than other forms of action-led investigations like practitioner-research and pedagogical action research is our dual aim to improve practice *and* develop new methodological and theoretical insights for the problem-based research community (Capobianco & Feldman, 2006).
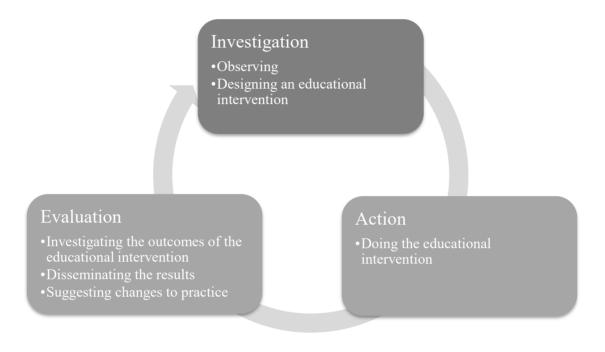
Figure 1. The Educational Action Research Cycle.

In our research, the investigation and action phases were led by the second author, while the evaluation phase was led by the first author. The third author supported the research by transcribing the interviews and performing the literature review. The last author had a supervisory role.

Investigation. The investigation phase lasted six months, from the start of the academic year in September 2020, until the start of Experimental Pedagogics in February 2021. The investigation phase was initiated in response to a request from the University's Diversity and Inclusion Office (DIO) to develop a training programme to sensitize university students to early outreach issues in socio-economically deprived areas of Rotterdam. When the coronavirus pandemic hit, working with primary and secondary schools in Rotterdam became fraught. The DIO's mandate was therefore broadened to sensitizing students to diversity and inclusion issues in education. In the months that followed, the authors led informal consultation sessions with key players in diversity and inclusion and education innovation, at the University and outside the university, to obtain insights into

what might be included in the training design. The authors designed a 16-week extra-curricular training programme, as described below.

Action: Experimental Pedagogics. The pilot programme in Experimental Pedagogics (XP) ran as an inter-faculty extracurricular for undergraduates at Erasmus University Rotterdam in The Netherlands in the Spring semester of 2021. Due to pandemic lockdowns, the entire programme ran online as shown in Table 1.

Week	Project Track	Education Track	Reflection Track
1	Introduction Project Work Training		Intake Interviews
2	Topic Selection Group Contract	Lecture: Cognitive levers of learning	
3	Research Design	Problem-based learning: Scaffolding	Reflection Diary 1
4	Initial Problem Analysis	Lecture: Individual Levers of learning	
5	Initial Problem Analysis	Jigsaw classroom: group-based learning methods	Reflection workshop 1: cognitive & phenomenological reflection
6	Problem Reformulation	Lecture: Group Levers of learning	
7	Problem Analysis	Case-based learning: successful classroom experiments	
8	Problem Analysis		Reflection Diary 2
9	BREAK	BREAK	BREAK
10	Finalize the Problem	Lecture: Societal Levers of Learning Workshop: Build Blocks of Educational Experiment	Reflection workshop 2: group & societal reflection
11	Experiment Design	Object-based learning: writing the implosion	
12	Experiment Design	Lecture: Global Levers of Learning	Reflection Diary 3
13	Experiment Design	Design-based learning: Education for 2100.	
14	Experiment Design		Deadline Articulated Learning Reflection
15	Deadline Project Report		
16	Group Project Presentations		Exit interviews

Table 1. Week-by-week, Track-by-track Structure of the XP Programme.

Project Track. The project track closely follows the Roskilde Model of PPL (Andersen & Heilesen, 2015). The step-by-step approach listed in Table 2 is adapted from Holgaard et al. (2017). We developed scaffolded worksheets to accompany each step. Students formed groups of 3-5, and identified a real-world educational problem on the theme of diversity and inclusion in an educational setting of their choice. Due to access constraints caused by coronavirus lockdowns, we did not further restrict their choice of problem: two groups worked with higher education, two groups with high school and one group with primary school problems. Three groups worked with Dutch institutions, two with institutions in the home country of one of the team members (Poland and Bulgaria). The problems covered LGBTQ issues, racial-ethnic diversity, the urban-rural opportunities gap, neurodiversity and xenophobia directed towards Roma children. The project deliverable was an education intervention plan, with a background research report on the problem (literature review and stakeholder interviews or surveys), and a detailed outline for a classroom experiment to address the problem.

Education Track. The education gave students the theoretical knowledge and skills to design their educational experiment, structured into five levels of increasing scope and breadth.

- The cognitive level covered traditional educational sciences and cognitive theories of learning, including constructivism, self-determination theory, information processing, and instructional design (Ryan & Deci, 2020; Sweller et al., 2019).
- The individual level addressed the existential and phenomenological importance of learning, using existential and embodied phenomenology to introduce students to concepts of agency, purpose, choice and self-authoring (De Beauvoir, 1947; Merleau-Ponty, 1945).
- The group level drew upon psychodynamic understandings of group work and the Karpman triangle to uncover how classroom group interactions can function or malfunction (Bion, 1968; Emerald, 2016).
- The societal level covered classic and modern critical pedagogy (Arendt,1961; Biesta, 2020; Freire, 1968; hooks, 1994; Negt, 1974).
- The global level situated education within a broader technological, socio-economic and environmental threats and opportunities (Dumit, 2014; Haraway, 2016).

Within the education track, classes were taught using an array of problem-oriented, student-centred pedagogies including problem-based learning (Moust et al., 2021), jigsaw method (Aronson & Patnoe, 2011), case-based learning (Ellet, 2018), object-based learning (Dumit, 2014) and other bespoke workshop formats tailored to developing specific skillsets such as constructive alignment and educational design.

Reflection Track. The reflection track mapped onto the education track, with levels of reflection corresponding to the different educational levels covered in the education track, ranging from cognitive reflection to critical and intersectional reflection.

The reflection track comprised the following learning moments:
- 30-minute individual intake interview: students were asked about their background, their motivation for joining, and formulated programme learning goals for themselves.
- Individual learning diaries: students wrote personal reflections using written prompts adapted from Ash and Clayton (2004) (refer to Appendix 2). There were three hand-in moments for learning diaries, spaced out to give students time to absorb their learning experience, process it in the workshops, and grow from experience before writing the next one.
- Reflection workshops: workshops took place at strategic moments of the programme, after students handed in a learning diary. In the workshops, students used their diaries as primary sources for meta-reflection exercises using different theoretical lenses to help them interpret their experiences. The four levels of reflection were:
  - Cognitive: students interpreted their diaries through the lens of the Kolb learning cycle (Kolb, 1984).
  - Individual: students interpreted their diaries through the lens of phenomenological analysis (Eatough & Smith, 2017; Feilberg, 2016).
  - Relational: students interpreted their diaries through the lens of Karpman's drama triangle and the empowerment dynamic (Emerald, 2016).
  - Societal and Global: students interpreted their diaries through the lens of the sociological imagination, focusing on exemplarity (Mills, 1959; Negt, 1974).
- Written Articulated Learning Reflection: we adapted Ash and Clayton's (2004) Articulated Learning to cover all three learning moments of the diaries, instead of one discreet event. Students were asked to trace a learning arc across their learning experience for the whole programme, and interpret that arc at all four levels of reflection covered in the programme.
- 30-minute individual exit interview: students were asked about their experience and key takeaways of the programme, and to assess the outcomes of their learning goals. The interviews for this study were performed immediately afterwards.

Evaluation: using phenomenography in EAR. Although Cherry (2005) suggested more than fifteen years ago that phenomenography might be a useful tool for action researchers, Beaulieu (2017) noted that the call had not been heeded by action researchers. He argued that phenomenography's emphasis on divergence and variation might make a powerful

contribution to diversity and inclusion in action research. He stated: "infused by phenomenography, action research can lead to a deeper understanding of diverse views and inspire solutions for addressing the educational disparities we continue to experience" (p. 64). We harnessed the second author's prior experience with phenomenography to design our evaluation with phenomenographic principles in mind.

While most qualitative research approaches seek common themes underlying the studied phenomenon, phenomenography investigates variations in conceptions of the phenomenon (Bowden & Green, 2005; Marton, 1986; 1986). That is, it tries to grasp how people can interpret the same phenomenon differently. As Marton and Booth suggested (1997, p.111), there is a strong relation between how one experiences a given situation and how one acts upon it: "To make sense of how people handle problems, situations, the world, we have to understand the way in which they experience the problems, the situations, the world, that they are handling or in relation to the way they are acting (…). You cannot act other than in relation to the world as you experience it". An approach focused on variation rather than common themes provides an opportunity to bring uncommon or marginalized perspectives to the fore and consider them on an equal footing with more common perspectives. Therefore, we believe that phenomenography can enrich the critical pedagogical toolbox by challenging educators to understand and situate different conceptions of the educational experience in relation to each other.

The outcomes of a phenomenographic analysis are a series of categories that define an outcome space. This space is a graphically represented map of all identified conceptions, such that the relationship between the different categories, and between the categories and educational objectives becomes apparent. In our case, different categories or conceptions emerged from the data based on the different way in which participants experienced reflection. The outcome space describes a hierarchical, logical relationship between emergent categories. Phenomenography posits that categories of conceptions ought to be logically connected since different conceptions represent different relationships between the studied phenomenon and how people experience it (Åkerlind, 2005). Categories in the outcome space are organised hierarchically, which does not imply a value judgement on conceptions, but denotes that some categories are more complex or broader than others (Åkerlind, 2005; Marton & Booth, 1997). The aim is to describe the qualitatively different ways participants experience a phenomenon in a useful and meaningful way for practice, showing what would be needed for a student to move from a less complex to more complex ways of understanding a classroom phenomenon (which could be related to classroom content or process). Therefore, there is a continuous iteration between defining the categories and clarifying the logical relationships between them (Bowden & Green, 2005). As phenomenographic research explores the variation of students' experiences of a given phenomenon, this allows for a way of looking at the

collective experience of the phenomenon holistically (in contrast to the individual experience each person might have about the phenomenon).

This research method has been used to explore the impact that educational programs might have on students' experiences of certain classroom phenomena. Phenomenographic analysis has been conducted to explore, for example, students' experiences around engagement and creativity (Reid & Solomonides, 2007) or around programming (Stamouli & Huggard, 2007). In problem-based education, Dringenberg and Purzer (2018) studied variations in conceptions of ill-structured problems, Servant-Miklos and Kolmos (2022) examined variations in conceptions of problem and project based learning, while Mohd-Ali et al. (2016) used a PBL setting to explore methodological questions in phenomenography. In the area of reflection, Prinsloo, Slade, and Galpin (2011) explored how students experienced online reflection diaries. Given the popularity of phenomenography as an educational research method, we were able to adapt existing research tools towards an EAR framework, including interview protocols, sampling procedures, interview approaches and analysis.

Interview protocols. We developed a two-part semi-structured interview protocol modelled on existing phenomenographic protocols by Dringenberg et al. (2018) and Zoltowski et al. (2012), adapted to the EAR framework. The first part focused on descriptive elements of participant experiences in XP. The second part focused on reflection, divided into experiential questions, and what Zoltowski et al. called "summative questions" (2012, p. 58), i.e. questions that elicit more explicit formulations of participants' conceptions of reflection. The key adaptation to the protocol made for EAR is the context-boundedness of the questions, rather than more general or abstract experiences of reflection. The full protocol is provided in Appendix 1.

Participants. In EAR, sampling is purposive and context-bound (Etikan, 2016), i.e. researchers sample participants according to their proximity to the educational phenomenon being investigated. In phenomenography, sampling aims to maximise variations in demographic characteristics within the target group (Åkerlind et al., 2005). To resolve this, following Daly et al.'s contention that sampling should reflect variations occurring in the target population (2012), we sampled the entire population of XP. Of the 20 students who signed up for XP initially, 17 stayed until the end. We therefore utilized the data of 17 participants for this study, which is within the range of participants required in phenomenography to avoid any common conceptions being missed (Servant-Miklos & Kolmos, 2022). Following the norms on ethical research, all students were given an option to opt out of research participation without affecting their enrollment in XP. However, none chose to opt out. Before the start of XP, all students signed an informed consent form detailing the research process, the data collection points and the storage and use of data.

Pseudonym (randomly assigned)	Faculty	Nationality (Dutch / International)
Ada	Social Sciences	Dutch
Carol	Economics	International
Catherine	Social Sciences	International
Chima	Liberal Arts & Sciences	Dutch
Cornelia	Liberal Arts & Sciences	International
Daphne	Philosophy	Dutch
Freya	Social Sciences	Dutch
Felicia	Liberal Arts & Sciences	International
Gabriele	Media & Communication	Dutch
Hetti	Liberal Arts & Sciences	International
Iria	Liberal Arts & Sciences	International
Jessica	Social Sciences	International
Livia	History	International
Pia	Social Sciences	Dutch
River	Liberal Arts & Sciences	International
Sadie	Social Sciences	International
Samira	Social Sciences	Dutch
Sandra	Social Sciences	International
Valentine	Liberal Arts & Sciences	International
Yuri	Social Sciences	International

Table 2. Participant Table.

Interviews and Transcripts. As indicated in Table 1, we conducted the interviews during the last week of XP. The first and second author split the student group randomly and each conducted half of the interviews. Due to the lockdown measures in place at the time, all interviews were done online. Interviews lasted about one hour each, and were all conducted in English as this was the language of XP. The interviews were recorded with the permission of the participants, then the audio recordings were given to the third author who transcribed them. All transcripts were pseudonymized.

Analysis. There are two schools of thought on analysis in phenomenography: pure and developmental. Pure phenomenography looks for conceptions within sections of transcripts and across different transcripts (Marton, 1986; Marton & Booth, 1997). Developmental phenomenography assigns one conception to one transcript as a whole unit, then groups transcripts that display similar conceptions (Bowden & Green, 2005).

Pure phenomenography is used when researchers are interested in variations within transcripts. Developmental phenomenography is useful when researchers are interested in a broader view of variation across the group of participants. We used the developmental approach. We began by reading repeatedly the entire set of transcripts in an iterative and comparative process. The transcripts were then sorted into piles with similarities and differences outlined. From there, categories related to each transcript as a whole emerged from the content of the interviews, rather than any theoretical framework from the literature. After several iterations, the categories were clarified and refined. This allowed for the development of the structural relationships between the categories which laid the foundations for the two axes forming the outcome space. The first author played the lead in the categorization process, with the second and third author playing "devil's advocate". Although there is no prescribed way to visualize the outcome space, we followed Zoltowski et al (2018) and Dringenberg and Purzer (2018) in designing a matrix outcome space in which categories follow an upward, rightward trajectory (Figure 2).

FINDINGS

The Outcome Space

The analysis revealed seven qualitatively different ways in which participants understood and practiced reflection within XP. An overview of the categories can be found in Table 3.

Categories	Summary
Category 0 Hetti, Yuri, Sandra, Valentina, Samira, Pia, Iria (all prior to XP)	Reflection is for the teacher and for the course, not for the students. Reflection is being forced upon and does not add to the learning experience of the students. It is deemed irrelevant and of no added value.
Category 1: Personal Reflection Ada, Frida, Helen, Livia, Sadie, Youri	Reflection is for personal growth and development. The focus is on the individual and on self-awareness. A depth in the reflection starts to emerge in comparison to previous experiences. Yet, it lacks appreciation for other perspectives and for deeper level of analysis.
Category 2: Relational Reflection Jess, Sandra, Valentina	Other people's inputs and experiences start to become a crucial component of the reflective process. Interacting with others begins to become an integral part of the reflection. It can be that close friends or family help with the reflection or that other inputs are being considered. Nevertheless, the focus is still on the self, the goal is still self-development.

Category 3: Societal Reflection Carol, Cornelia	Reflection has become critical in so far as other perspectives and actors are being taken into consideration. Other people's insights, perspectives, values are seriously included in the reflection process. The goal and focus of the reflection have moved outside of the individual to include others and society at large.
Category 4: Metacognitive Reflection Catherine, Pia, Samira	Reflection gains a deeper level of analysis. Gaining a stronger and deeper sense of self-awareness in relationship with other people helps to build the foundations to develop this meta-understanding of reflection. Connections start to become visible. The focus is still on the self but the meta level allows for one to direct and guide one's development.
Category 5: Critical Reflection Gabriele, Iria	Reflection has gained both depth and breadth. The deeper level of analysis moved beyond the self to include and take into consideration their contexts, the community, and society at large. Reflection becomes critical, deep, and societally engaged.
Category 6: Fractal Reflection Daphne	Reflection has become too complex and chaotic. Complexities and confusions emerge when exploring deeper and broader elements of reflection. Without sense-making frameworks, reflection can turn into an inefficacious, self-destructive tool.

Table 3. Categories of Description of Students' Experience of Reflection.

The seven categories formed an outcome space with two distinct, yet related, axes: "Depth of Reflection" and "Breadth of Reflection", as shown in Figure 1. The former describes the depth of students' reflection across different levels, moving from a more superficial self-reflection towards a more profound level of reflection, then tipping into downward, regressive spiral of continuous reflection on reflection. The second axis outlines the extent to which students' reflection involves other actors, ranging from being self-referential to include others and the society at large.
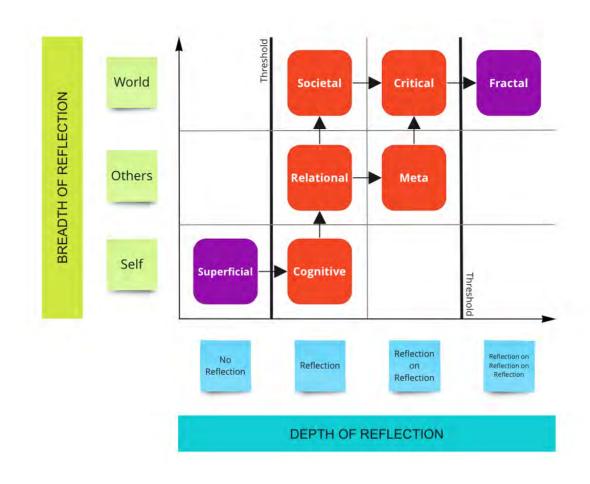
Figure 2. The Outcome Space of Conceptions of Reflection in a Problem-based Environment.

The Categories of Experience

Each category is ordered in such a way that subsequent categories describe a more comprehensive way of understanding and practicing reflection. The qualitative differences between the different categories enabled us to develop the hierarchical structure shown in the outcome space. Five of the seven categories, namely Category 1 to 5, were related in such a way that each subsequent category represented a more sophisticated and comprehensive way of experiencing reflection. Although logically related to the other ones, Category 0 and 6 do not fall in that group. This shows the existence of a reflection "sweet spot" in the outcome space. Inside of the "sweet spot", students go one or two levels deep in one or both axes. Outside the "sweet spot", students either do not reflect at all (as shown by students' experiences prior to this project - Category 0), or become so entangled that an infinite regress appears to derail learning (Category 6). Inside of this "sweet spot", categories that are more sophisticated contain elements that are unique to them as well as elements that are present in less comprehensive categories. Category 0 emerged in conversations with the students as the most common understanding and practice of reflection before entering the programme.

Category 0: Superficial reflection. Many students described how they previously disliked the idea of reflecting, deeming it of no value. It was experienced as imposed and geared towards knowledge and facts, which compounded a feeling of detachment and alienation. Hetti and Samira best described the transition away from this form of reflection during XP.

> Samira: My view of reflection really went from something that you have to do, and that I would write in half an hour because you have to do, to make something out of it, to really think about what you write, what you did, what you learned.
>
> Hetti: guess before I would just have answered that reflection is more for the teachers, but I now see it as something more for myself

What helped students to move through this transition was certainly the time and space in the programme devoted to reflection. However, something that was of particular importance was the creation of a psychologically safe environment.

> Youri: When I realised it is not judgmental, I felt a bit released and accepted. I think that I realised it is a safe space in which I can put my thoughts, instead of a place where I need to spill out my personal life. I think that in the first reflection I was very protective. Later I built trust and realised the importance of it.

This transition was experienced by many students, regardless of what categories they fell into later.

Category 1: Personal reflection. Participants in this category developed a view on reflection which revolves around their own personal growth and development. They claimed to have experienced a greater sense of self-awareness as they developed more open and exploratory mindsets. Moving beyond a view of reflection as shallow, teacher-centered, and content-oriented, now students started to regard it as an integral and meaningful part of their own development.

> Ada: Reflection is thinking back of an experience, and trying to... Yeah, maybe almost like relive it. But relive it from different aspects, or relive it from the cognitive level, or the phenomenological level and really evaluate it and work out details, so you can make it more meaningful and learn from it. Because I think that when you experience something you are so caught up in the moment and you, you... because you are in the moment, you have to act on it. And when you reflect on it afterwards, you don't have to act on it anymore because the moments is past. So that gives you, I think, a little room to look back and really learn from it.

Students in this category started to appreciate the distinction between experiencing and learning from the experience. It is this focus towards meaning and learning that defines this category, transitioning away from the previous one. Personal growth and

development became crucial in their understanding and practice of reflection. They started to reflect on how their everyday experiences related to each other and to themselves, how they could derive learnings and incorporate those learnings in their own lives, in line with their own goals and actions. Felicia framed this in her own way when pondering on how self-reflection can become a tool to know one's strengths and weaknesses.

> Felicia: I don't think there's like a wrong or right way to do it, of course. But yeah, I think it helps you see where your strengths and weaknesses are. (...) It does allow you to I don't know, to not to get I mean, certainly like to get to know yourself, but it's not that deep. I think. Yeah, I mean, it does help, it does help you to see your strengths and weaknesses.

Yet, these students were still focused on their own personal growth and development, without taking into account other perspectives or taking a step back to re-evaluate or re-examine their viewpoints. Their conception revolves around bettering themselves, improving their weaknesses and leveraging their strengths. Their reflections, while beginning to show signs of depth and awareness, were still very much self-centered and solution-oriented.

Category 2: Relational reflection. Participants in this category developed a view on reflection that started to include other people and other perspectives. They started to see how reflection could be beneficial for the group process. Being able to share, talk, and discuss with others became a crucial component of the reflection process. In describing an important moment in her development, Sandra reported how feedback and other people more generally played a valuable role in her learning.

> Sandra: The feedback really helped me I think. Even if it was just like, oh, wow, that sounds a bit depressive. I don't know, it just it really, maybe it's my personality type. But I really like getting other people's view on things, even if it's a view I disagree on. But still, I think it adds so much value.

Within the outcome space, students in this category moved up the axis "Breadth of Reflection" as they developed a more critical view on reflection that includes and considers other inputs and perspectives. Being able to reflect with others becomes more meaningful and exciting.

> Valentina: In my group projects, we had to reflect sometimes about how the interviews we were carrying out went and I got much more enthusiastic, because then you get, I don't know, triggered by other people, other people's experiences and what they say and, and my reflection felt much more complex when I was doing with people than on my own.

However, the focus of their reflection is still around self-development and growth. Ultimately, students in this category still saw others as a way to improve themselves, seeing self-development and personal growth as the purpose of reflection. Moreover, students started to show signs of a deeper level of reflection, although they cannot yet be qualitatively defined as having reached a metacognitive level of reflection.

Category 3: Societal reflection. At this level, students showed a wider understanding and practice of reflection, regarding the spectrum of actors involved. Students in this category started to seriously consider other people's perspectives, backgrounds, and values when reflecting on certain learning moments. They discovered how the center of their reflection can move outside of themselves to encompass people, communities, and larger societal issues. In contrast to the previous categories, the focus was no longer solely on personal growth. Here the purpose and meaning of reflection had a more critical and engaged tone. In defining what reflection is to her, Carol clearly explained this new level of engagement in her reflection.

> Carol: I always thought that reflection was like a very personal thing, like, takes a personal approach. So additionally, now I see that it can also be through someone else's eyes. Now I understand reflection, also, the ability to connect your experience or situation to something much wider, like societal issues.

One can see an application of Carol's definition in how Cornelia described one of her reflection moments. By being critical and aware while taking diverse perspectives into consideration, Cornelia tapped into the relationship between a set of systemic issues and her own project work.

> Cornelia: I tried to feel empathy for the people who are discriminating against Romani people. At the same time, I also feel empathy for Romani people as well. So, I was looking at different perspectives, like how they look at Romani people, how Romani people look at Bulgarian people. It was like I was being Romani people. And I was like, okay, they see us as criminals, which is making me act upon it more, you know, the way that, like… I feel like I'm an outcast, and the country that I live in is making me… I don't know, do impulsive stuff, probably I wouldn't like to be a minority in the country that I'm living.

While this showcases a radically different level of analysis than in the previous categories, students in this category still have not yet been able to tap into the depth of their reflection, the second axis of the outcome space. This other dimension begins to emerge in the subsequent categories.

Category 4: Metacognitive reflection. The main difference between this category and the previous ones relates to the axis "Depth of Reflection". While previous categories showed an increased level of sophistication in relation to the axis "Breadth of Reflection",

the following categories explore how the change across the two axes show an increasingly comprehensive view of reflection. Students in this category did not necessarily develop the broad analysis found in Category 3. Nevertheless, their understanding and practice of reflection is built upon Categories 1 and 2, as shown in Figure 2. Participants in this category developed a more comprehensive idea of reflection that revolves around self-awareness and personal growth. They also started to appreciate other people's input in the process. It is thanks to these two developments that participants engaged in a deeper level of reflection. Catherine outlined her reflection process and showed how being metacognitive was the most crucial component in allowing her to create connections and depth in her learning.

> Catherine: I think the most difficult part is just before the last step, you have to reflect on your reflection. So don't forget it, don't just like, do it once, and then put it away and never read it again. But read it, and then do it on a frequent... like do it frequently. And then finally, try to, to link it together, try to link your different, like, critical moments in life together. Just try to link it together to see, is there any common things between those moments? So by seeing the similarities and the differences, you maybe can learn a new thing about yourself.

This metacognitive perspective in the reflection process enabled students in this category to develop a clearer sense of self-direction. Reflection became a pivotal tool for awareness and action. Students took initiative for their own education: they started to identify their learning needs and goals and to initiate, monitor, control and evaluate their learning process to reach their goals and meet their needs.

> Pia: It makes you more aware of the learning moments, and also makes you more aware of how much you've already learned. And yeah, also to be able to see what learning goals you could set for further process. Because when you're looking back at where you're at, right now, you're also able to set a goal for where you want to be.

As with Category 2, students were able to position themselves outside of themselves, to include others in their own reflections and evaluations. That is, they developed a more in-depth reflective process while starting to open up to others' inputs and perspectives. However, the focus of their reflection still revolved around self-development and growth. It is with the next category of experience that the students were able to combine both metacognitive and societal elements to their reflection to develop a critical view on reflection.

Category 5: Critical reflection. Participants in this category experienced a more sophisticated reflective and critical perspective on reflection. Alongside the two axes, they started to include a wide variety of actors and perspectives in their reflection while acknowledging the importance of stepping back to develop in-depth understandings and

practices. Students' perspectives became critical in so far as they took into consideration the world and the context around them, questioning their identity and positionality in society. That is, they were able to take a metacognitive perspective on their experiences which was informed by people and societal factors. This can be seen in Iria's words when she reflected on her project work and how that made her develop a more critical stance towards herself and society.

> Iria: I started to question my position in this project, with, like, I don't know, stepping into the foot of a different country and a community that is completely unrelated to me in some ways. I think that those critiques based on yourself are super valuable. And if you do not leave time to for this reflection, so maybe you don't even realize, and you think you're actually doing something positive, which might not be positive. So yeah, I think that was a point where I realized like, okay, like, think twice about what you're doing.

Students in this category considered other people's inputs, perspectives, situations in their thinking and reflecting. They also understood the importance of reflecting on reflection, on taking step backs and reconsider or re-evaluate the situations further. When asked why she found reflecting with societal and critical lenses to be striking and interesting, Gabriele gave the following explanation:

> Gabriele: You can really articulate in a deeper way, think about what you're doing. And why you're doing it, and also be critical on things that you shouldn't do, or the way you're doing it.

Category 6: Fractal reflection. In this last category, participants reached beyond the sweet spot of reflection by getting entangled in an infinite reflection regress. They developed a broad sense of awareness, which allowed them to question themselves and their positionality in society. However, they also entered a regress which made it harder for them to reflect in a meaningful and constructive way. Students in this category were no longer able to make sense of their reflection, derailing their learning process. Thus, an internal conflict emerged between a sense of development in their critical practice and understanding of reflection and society against a sense of complexity, loss, and confusion. This tension can be seen in Daphne's words as she described how her view of reflection changed over the course of the program.

> Daphne: Yeah, I think I did a lot more reflection than I thought of the first time. And, it also made it harder to reflect (…) Because I was thinking about thinking about thinking about thinking. On and on. That makes it hard to just write something.

This created a sense of chaos and derailment. It became impossible to make sense of the complexities and nuances of learning. When one cannot stop reflecting and enter an

infinite reflection regress, life becomes overwhelming and ungraspable. The more they explore, the harder and more complex it becomes.

Relationship between the categories. Table 4 clarifies the main relationships across the different categories.

Categories	Relationships
0 ->1	Having the time and the space to properly reflect becomes vital in the transition from a shallow reflection to experience a more meaningful and personal dimension.
1 -> 2	Finding a stronger sense of personal growth and development in the reflection process is conducive to start appreciating others' inputs and perspectives.
2 -> 3	Considering other people's inputs in the reflection process is a first step towards taking seriously into account the insights, opinions, and values of others and the society at large.
2 -> 4	Having a stronger sense of self while learning to appreciate the others can lay the foundations for a metacognitive understanding of reflection.
3 -> 5	Becoming more aware of the way others and society at large can affect one's experience and reflection is necessary to develop a critical and in-depth view on reflection.
4 -> 5	Developing a deeper sense of oneself and one's experience is conducive to becoming engaged in a critical and socially engaged reflection.
5 -> 6	Engaging in both the breadth of the possibilities and the depth of the layers of reflection might lead towards a fragmented, confused, and complex view of oneself and the world.

Table 4. Relationships between Categories of Description.

DISCUSSION

The category descriptions and the relationships between the different categories that make up the outcome space reveal a number of important points for the practice of reflection in a problem-oriented environment.

Firstly, we related the experience of reflection to two dimensions: breadth and depth. This means that reflection can be interpreted along two independent, yet interconnected aspects. On the one hand, students can engage with aspects of reflections that take into account a larger set of actors. On the other hand, students can experience a type of

reflection that taps into deeper levels of thinking. Secondly, the categories are nested hierarchically with clear relationships and dependencies between them. In particular, categories 1 to 5 show a development of reflection, with category 5 describing a more comprehensive and sophisticated approach. Categories 0 and 6, however, outline the lower and upper threshold, respectively, within which students' reflection leads to meaningful learning experiences. Within the growth zone, students increasingly reflect on their learning experience in a systemic way, embedding individual experiences in a societal context, cutting across local and global issues.

We can conclude that the structured reflection programme of XP infused students' project work with critical exemplarity (Negt, 1974; Servant-Miklos & Guerra, 2019). As discussed earlier, in the 1980s, PPL drifted towards a cognitive, skills, and competence-based learning framework. Our findings show that the XP reflection programme went beyond reviving the critical framework of PPL. Being able to grasp the interconnectedness between the classroom and the bigger picture allowed students to step outside of their personal experience, into an intersectional public sphere where other perspectives, values, belief systems, and behaviours can be acknowledged as meaningful, valuable and woven into complex interconnected patterns that affect people's chances and challenges in life. In this sense, our approach to reflection is more alligned with intersectional approaches to critical education (e.g. Carbado et al., 2013; hooks, 1994).

Reflection as Praxis

Servant-Miklos and Noordegraaf-Eelens (2021) argued that, for social-transformative action to take place in the learning process, students need to connect personal reflections on learning with social impact in an action-reflection cycle. They reference Freire's educational praxis:

> We find two dimensions, reflection and action, in such radical interaction that if one is sacrificed – even in part – the other immediately suffers. There is no true word that is not at the same time a praxis. Thus, to speak a true word is to transform the world. (...) When a word is deprived of its dimension of action, reflection automatically suffers as well; and the word is changed into idle chatter, into verbalism, into an alienated and alienating "blah." It becomes an empty word, one which cannot denounce the world, for denunciation is impossible without a commitment to transform, and there is no transformation without action (Freire, 1968, p.87).

Our findings demonstrate both ends of the praxis: Category 0 represents action without reflection, Category 6 represents reflection without action. While the benefits of supplementing content learning with reflection are thoroughly documented in the PBL literature, the impact of an overemphasis on reflection at the expense of action is less so.

Perhaps this is because the two fields in which PBL is used most extensively, namely medicine and engineering, are geared towards action by the nature of the professions they feed into. In the humanities, Servant-Miklos and Noordzij (2021) identified an instance in which students, who learned about the climate crisis in a PBL course with no action outlet, developed despairing thoughts, harming their mental health and failing to effect personal and social change. Feilberg (2016) noted the importance of supervisor guidance and intervention in spurring students' productive introspection on their (unconscious) personal and professional motives in the project learning process. He suggested that supervisors might help students realize when their personal experience leads them to overanalyze project data, a point also made by Jensen (2015). Broadening this argument, we might suggest that by channeling students towards productive reflection (i.e. reflection in praxis) supervisors play a guard-rail role against falling into Category 6.

The context of XP lends itself well to such stewardship: given the small-scale, close-knit learning community created in XP, students built trusting relations with their supervisors and the interview quotes show that they were receptive to guidance and feedback. The context also channeled student energies productively: by giving them space and resources to apply the knowledge acquired throughout the course into project work with real life societal problems. Despite COVID, students' experiences were enhanced by their immersion in community research. The opportunity to engage with society and bring about change, even at a small scale, gave students a sense of agency while teaching them valuable skills about engaging with external stakeholders.

Implications for practice

Our findings suggest that using a structured, multi-dimensional reflection approach in a problem-oriented learning environment can lay the foundations for a more critical, intersectional and engaged relationship with the others and the world. Given the urgent and complex nature of the world's interlocked sustainability and equity crises, keeping PBL in step with the educational challenge posed by these crises will be essential to its future-proofing. In this regard, there are concrete implications for practice to be drawn from this study.

Firstly, we call to attention the role of supervisors in fostering productive, critical reflection. To appraise students' motives, it is essential for educators themselves to invest in a thorough self-reflection process. Educators can scarcely remain indifferent to the fate of humanity when the planet is on fire, to socio-economic injustice at times of extraordinary inequality, or to racial, gendered, sexual and other forms of oppression at a time when powerful interest groups seek to roll back progress. However, it is necessary for educators to be aware of their motives and make them explicit, exemplifying self-reflective practices for students, and creating a basis for dialogue. Students engaged in a reflection process are in a vulnerable situation of self-growth. Educators must be

especially conscious not to impose their dearly held worldviews on students, but to let them grow and evolve their own.

This means, therefore, challenging classroom dynamics. PBL already challenges the traditional student-teacher relation, replacing it with a more collaborative arrangement that varies in teacher-direction depending on the model of PBL (Servant 2016). However, building on the transgressive work of hooks (1996), we suggest that structured reflection practices within project work have the potentiality to engage students and teachers in a more fully human collaboration in which pathos and eros are given space on par with logos.

In the decades since PBL's inception, it has been increasingly instrumentalized by employability discourses, focusing on creating work-ready graduates with marketable competences and skills (e.g. Johnson et al., 2015; Mann et al., 2020; Mitchell et al., 2019). The language of future-proofing in PBL literature has coalesced around skills and competences required for a future that is imagined as a technologically richer continuation of the present, even in the context of sustainability education (e.g. Kolmos et al., 2020). It is becoming increasingly probable that such a future will elude us, and we must instead prepare for a future of resource scarcity, runaway global heating, and ongoing civil and international humanitarian crises (Kemp et al., 2022).

In this context, it is as important as ever to develop what Freire (1968) and hooks (2003) called a pedagogy of hope. Being hopeful doesn't mean placing one's faith in outcomes that cannot materially be realized, such as hoping to avoid climate catastrophe by escaping to Mars – such wishful thinking constitutes a form of denial, as Servant-Miklos & Noordzij (2019) showed, which is fairly common in PBL in engineering education. In the context of Experimental Pedagogics, hope means helping students to accept themselves as incomplete, and therefore open to a search that can be carried out in relationship with others, through the reflective praxis of problem-oriented project work. Such an approach can be conducive to an education in which new relationships between people and the world may be established, which in turn may lead to something unexpected and unpredictable (Biesta, 1998). This would help PBL move away from an instrument for professional development, towards a view that sees problem-based education as a rupture, as a new beginning whereby new possibilities and realities can be imagined.

Conclusion: closing the EAR cycle

Investigating student reflection experiences in XP with a phenomenographic action research design has been a very productive way for us to reflect on our own teaching practices, with the start of the second iteration of XP in mind, as a semester-long Minor from September 2022. Key to improving our practice is the finding that there is such a thing as too much reflection, and that soft scaffolding guardrails and clear pathways

towards action should be put in place to prevent this from happening. We might also think to amend our hard reflection scaffolds, such as the worksheet presented in Appendix 2, to include action prompts. Perhaps, borrowing from Feilberg (2016), we, as teachers, might more explicitly model what reflection praxis looks like for students. This means we may need to take some of our own medicine and practice multi-dimensional, structured reflection on ourselves, before we ask the same of students. To some extent this study participates in that effort, but we may also explore the individual motives and drives that bring us, as teachers, to Experimental Pedagogics, with a view to creating a space, where, to paraphrase Biesta (1998), we can release the possibilities of critical pedagogy.

References

Åkerlind, G. S. (2005). Variation and commonality in phenomenographic research methods. *Higher Education Research & Development*, *24*(4), 321-334. https://doi.org/10.1080/07294360500284672

Åkerlind, G., Bowden, J., & Green, P. (2005). Learning to do Phenomenography: A reflective discussion. In J. Bowden, & P. Green, Doing Developmental Phenomenography (pp. 74-102). RMIT University Press.

Andersen, S.A. & Heilesen, S. B. (2015). *The Roskilde Model: problem-oriented learning and project work.* Springer.

Arendt, H. (1961). The Crisis in Education. In: Between past and future: Six exercises in political thought. New York: Penguin Books, 173-196.

Aronson, E. & Patnoe, S. (2011). *Cooperation in the Classroom: The Jigsaw Method.* Pinter & Martin Ltd.

Ash, S. L., & Clayton, P. H. (2004). The articulated learning: An approach to guided reflection and assessment. *Innovative Higher Education, 29*(2), 137-154. https://doi.org/10.1023/B:IHIE.0000048795.84634.4a

Ash, S. L., & Clayton, P. H. (2009). Generating, deepening, and documenting learning: The power of critical reflection in applied learning.

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-based learning: An approach to medical education.* Springer Publishing Company.

Beaulieu, R. (2017). Phenomenography: Implications for expanding the educational action research lens. *The Canadian Journal of Action Research, 18*(2), 62-81. https://doi.org/10.33524/cjar.v18i2.335

Biesta, G. J. (1998). Say You Want a Revolution: Suggestions for the Impossible Future of Critical Pedagogy. *Educational Theory 48*(4), 499-510. https://doi.org/10.1111/j.1741-5446.1998.00499.x

Biesta, G. (2020). Risking ourselves in education: Qualification, socialization, and subjectification revisited. *Educational Theory, 70*(1), 89-104. https://doi.org/10.1111/edth.12411

Bion, W. R. (1968). *Experiences in Groups, and other papers.* Routledge.

Bowden, J. & Green, P. (2005) *Doing Developmental Phenomenography*. Melbourne, Australia: RMIT Press.

Carbado, D. W., Crenshaw, K. W., Mays, V. M., & Tomlinson, B. (2013). Intersectionality: Mapping the Movements of a Theory. *Du Bois review: social science research on race*, *10*(2), 303-312. https://doi.org/10.1017/S1742058X13000349

Capobianco, B. M., and A. Feldman. 2006. Promoting Quality for Teacher Action Research: Lessons Learned from Science Teachers' Action Research. *Educational Action Research 14*(4): 497–512. https://doi.org/10.1080/09650790600975668

Cherry, N. (2005). Phenomenography as seen by an action researcher. In: J. A. Bowden & P. Green (eds). *Doing Developmental Phenomenography.* RMIT University Press.

Daly, S. R., Adams, R. S., & Bodner, G. M. (2012). What Does it Mean to Design? A Qualitative Investigation of Design Professionals' Experiences. *Journal of Engineering Education, 101*(2), 187–219. https://doi.org/10.1002/j.2168-9830.2012.tb00048.x

Dahl, U., & Kennedy-Macfoy, M. (2022). Open Forum: Remembering bell hooks–A Roundtable. *European Journal of Women's Studies*, https://doi.org/10.1177/13505068221089874

De Beauvoir, S. (1947). *Pour une Morale de l'Ambiguité* [The Ethics of Ambiguity]. Paris: Gallimard.

Dringenberg, E. & Purzer, Ş. (2018). Experiences of First-Year Engineering Students Working on Ill-Structured Problems in Teams. *Journal of Engineering Education 107*, 442–467. https://doi.org/10.1002/jee.20220

Du, X., Spliid, C. M., Kolmos, A., Lyngdorf, N. E., & Ruan, Y. (2020). Development of critical reflection for transformative learning of engineering educators in a PBL-based professional learning program. *International Journal of Engineering Education, 36*(4), 1356-1371.

Dumit, J. (2014). Writing the implosion: teaching the world one thing at a time. *Cultural Anthropology, 29*(2), 344-362. https://doi.org/10.14506/ca29.2.09

Eatough, V., & Smith, J. A. (2017). Interpretative phenomenological analysis. In: C. Willig & W. S. Rogers (eds.). *The Sage handbook of qualitative research in psychology*, 193-209. Sage.

Ellet, W. (2018). *The Case Study Handbook: a Student's Guide.* Harvard Business Review Press.

Emerald, D. (2016). *The power of TED: The empowerment dynamic*. Bainbridge Island: Polaris Publishing.

Etikan, I. (2016). Comparison of Convenience Sampling and Purposive Sampling. American Journal of Theoretical and Applied Statistics, 5(1), 1. https://doi.org/10.11648/j.ajtas.20160501.11

Feilberg, C. (2014). *The formation of a psychological and scientific habitus in psychology students*. Doctoral Thesis. Roskilde University, Denmark.

Feilberg, C. (2016). Selvrefleksion som uddannelsesgreb - En Kritisk Diskussion. *Nordic Draft 43*(2), 42-61

Freire, P. (1968). *The Pedagogy of the Oppressed*. New York: Bloomsbury

Gay, G., & Kirkland, K. (2003). Developing cultural critical consciousness and self-reflection in preservice teacher education. *Theory into practice, 42*(3), 181-187. https://doi.org/10.1207/s15430421tip4203_3

Gibbons, J. (2019). Reflection, realignment and refraction: Bernstein's evaluative rules and the summative assessment of reflective practice in a problem-based learning programme. *Teaching in Higher Education 24*(7), 834-849, https://doi.org/10.1080/13562517.2018.1514374

Giroux, H. A. (2018). Pedagogy and the politics of hope: Theory, culture, and schooling: A critical reader. Routledge.

Hansen, E. (1997). *En Koral I Tidens Strøm* [a Coral in the Stream of Time]. Roskilde University Press.

Haraway, D. J. (2016). *Staying with the Trouble: making kin in the Chthulucene*. Duke University Press.

Hendry, G. D., Frommer, M., & Walker, R. A. (1999). Constructivism and problem-based learning. *Journal of Further and Higher Education, 23*(3), 369-371. https://doi.org/10.1080/0309877990230306

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn?. *Educational Psychology Review, 16*(3), 235-266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Holgaard, J. E., Guerra, A., Kolmos, A., & Petersen, L. S. (2017). Getting a hold on the problem in a problem-based learning environment. *The International journal of engineering education*, *33*(3), 1070-1085.

Hooks, B. (1994). *Teaching to Trangress: Education as the Practice of Freedom.* Routledge.

Hooks, B. (2003) *Teaching Community: a Pedagogy of Hope.* Routledge.

Illeris, K. (1974). Problemorientering og Deltagerstyring [Problem orientation and participant direction]. Copenhagen: Munksgaard.

Jensen, I. (2015) Methodological Challenges – From a Supervisor's Experiences. In Andersen, A. S., & Heilesen, S. B. (Eds.). The Roskilde model: Problem-oriented learning and project work. (pp.141-153). Heidelberg New York Dordrecht London: Springer Cham.

Johnson, B., Ulseth, R., Smith, C., & Fox, D. (2015). *The impacts of project-based learning on self-directed learning and professional skill attainment: A comparison of project-based learning to traditional engineering education*. Paper presented at the IEEE Frontiers in Education Conference, El Paso, Texas, USA. https://doi.org/10.1109/fie.2015.7344028

Kemp, L. Xu, C., Depledge, J. … Lenton, T.M. (2022). Climate Endgame: Exploring catastrophic climate change scenarios. *PNAS 119*(43), 1-9. https://doi.org/10.1073/pnas.2108146119

Kolb, D. A. (1984). The Cycle of Learning Experience. Englewood Cliffs, NJ: PrenticeHall Inc.

Kolmos, A., Fink, F. K. & Krogh, L. (2004). *The Aalborg PBL model: progress, diversity and challenges.* Aalborg University Press.

Kolmos, A., Holgaard, J. E., & Clausen, N. R. (2020). Progression of student self-assessed learning outcomes in systemic PBL. *European Journal of Engineering Education, 46*(1), 67–89. https://doi.org/10.1080/03043797.2020.1789070

Kuk, H. S., & Holst, J. D. (2018). A dissection of experiential learning theory: Alternative approaches to reflection. *Adult Learning*, 29(4), 150-157. https://doi.org/10.1177/1045159518779138

Landers, R. N. (2014). Developing a Theory of Gamified Learning. *Simulated Gaming* 45, 752–768. https://doi.org/10.1177/1046878114563660

Liu, K. (2015). Critical reflection as a framework for transformative learning in teacher education. *Educational review, 67*(2), 135-157. https://doi.org/10.1080/00131911.2013.839546

Mann, L., Chang, R., Chandrasekaran, S., Coddington, A., Daniel, S., Cook, E., Crossin, E., Cosson, B., Turner, J., Mazzurco, A., Dohaney, J., O'Hanlon, T., Pickering, J., Walker, S., Maclean, F., & Smith, T. D. (2020). From problem-based learning to practice-based education: A framework for shaping future engineers. *European Journal of Engineering Education, 46*(1), 27–47. https://doi.org/10.1080/03043797.2019.1708867

Marton, F. (1986). Phenomenography—a research approach to investigating different understandings of reality. *Journal of thought 21*(3), 28-49.

Marton, F., & Booth, S. (1997). *Learning and awareness*. Mahwah, NJ: Lawrence Erlbaum Associates.

McAteer, M. (2013). *Action Research in Education*. London, UK: Sage.

McNiff, J., & Whitehead, J. (2006). *All You Need to Know about Action Research: An Introduction*. London, UK: Sage

Merleau-Ponty, M. (1945/2005). *La Phénoménologie de la Perception* [Phenomenology of Perception]. Paris: Gallimard

Mertler, C. A. (2019). *The Wiley Handbook of Action Research in Education.* Hoboken, NJ: Wiley Blackwell.

Mills, C. W. (1959). *The Sociological Imagination.* New York: Oxford University Press.

Mitchell, J. E., Nyamapfene, A., Roach, K., & Tilley, E. (2019). Faculty wide curriculum reform: The integrated engineering programme. *European Journal of Engineering Education, 46*(1), 48–66. https://doi.org/10.1080/03043797.2019.1593324

Mohd-Ali, S., Puteh-Behak, F., Saat, N. S. M., Darmi, R., Harun, H., & Samah, R. (2016). Tackling the issue of credibility in Phenomenographic interviewing to capture Problem-Based Learning (PBL) experience. *Mediterranean Journal of Social Sciences 7*(4), 184-191. https://doi.org/10.5901/mjss.2016.v7n4p184

Moust, J., Bouhuijs, P., & Schmidt, H. (2021). *Introduction to problem-based learning: A guide for students*. Routledge.

Negt, O. (1974). *Soziologische Phantasie und exemplarisches Lernen: zur Theorie d. Arbeiterbildung* [Sociological Imagination and Exemplary Learning: towards a theory of worker's education]. Europäische Verlagsanstalt.

Noordegraaf-Eelens, L., Kloeg, J., & Noordzij, G. (2019). PBL and sustainable education: addressing the problem of isolation. *Advances in Health Sciences Education, 24*(5), 971-979. https://doi.org/10.1007/s10459-019-09927-z

Olin, A., Karlberg-Granlund, G. & Furu, E. M. (2016). "Facilitating Democratic Professional Development: Exploring the Double Role of Being an Academic Action Researcher." *Educational Action Research 24*(3): 424–441. https://doi.org/10.1080/09650792.2016.1197141

Ottesen, E. (2007). Reflection in teacher education. *Reflective practice, 8*(1), 31-46. https://doi.org/10.1080/14623940601138899

Prinsloo, P., Slade, S., & Galpin, F. (2011). A phenomenographic analysis of student reflections in online learning diaries. *Open Learning: The Journal of Open,*

Distance and e-Learning, *26*(1), 27-38.
https://doi.org/10.1080/02680513.2011.538562

Reid, A., & Solomonides, I. (2007). Design students' experience of engagement and creativity. *Art, Design & Communication in Higher Education*, *6*(1), 27-39. https://doi.org/10.1386/adch.6.1.27_1

Rogers, R. R. (2001). Reflection in Higher Education: A Concept Analysis. *Innovative Higher Education 26*(1), 37–57. https://doi.org/10.1023/A:1010986404527

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary educational psychology, 61*, 101860. https://doi.org/10.1016/j.cedpsych.2020.101860

Seibert, S. A. (2021). Problem-based learning: A strategy to foster generation Z's critical thinking and perseverance. *Teaching and Learning in Nursing, 16*(1), 85-88. https://doi.org/10.1016/j.teln.2020.09.002

Schmidt, H. G. (1993). Foundations of problem-based learning: some explanatory notes. *Medical Education, 27*(5), 422–432. https://doi.org/10.1111/j.1365-2923.1993.tb00296.x

Savery, J. R., & Duffy, T. M. (1994). Problem based learning: An instructional model and its constructivist framework.

Servant, V. F. C. (2016). *Revolutions and Re-iterations, an Intellectual History of Problem-based learning.* Doctoral Thesis. Erasmus University Rotterdam.

Servant-Miklos, V. (2020). Problem-oriented project work and problem-based learning:" Mind the gap!". *Interdisciplinary Journal of Problem-Based Learning, 14*(1). https://doi.org/10.14434/ijpbl.v14i1.28596

Servant-Miklos, V. & Guerra, A. (2019). Examining Exemplarity in Problem-Based Engineering Education for Sustainability. In *Proceedings of the 46th SEFI Conference,* pp. 1223-1232. Budapest, Hungary.

Servant-Miklos, V. & Kolmos, A. (2022). Student conceptions of problem and project based learning in engineering education: a phenomenographic investigation. *Journal of Engineering Education* https://doi.org/10.1002/jee.20478

Stamouli, I., & Huggard, M. (2007). Phenomenography as a tool for understanding our students. In International Symposium for Engineering Education (pp. 181-186). Ireland: Dublin City University.

Sweller, J., van Merriënboer, J. J., & Paas, F. (2019). Cognitive architecture and instructional design: 20 years later. *Educational Psychology Review, 31*(2), 261-292. https://doi.org/10.1007/s10648-019-09465-5

Zoltowski, C. B., Oakes, W. C., & Cardella, M. E. (2012). Students' Ways of
　　　Experiencing Human-Centered Design. *Journal of Engineering Education,
　　　101*(1), 28–59. https://doi.org/10.1002/j.2168-9830.2012.tb00040.x

APPENDIX 1

Interview protocol

Ask for permission to record the interview –
This interview is voluntary and you can stop your participation at any time.
Do I have your permission to record this interview?

The aim of this interview is to understand how you experienced the programme, how it impacted you and your life as well as what you will take from it moving forward. There are no right or wrong answers to these questions. You can take your time to think about your answer, and ask me to repeat a question if something was unclear.

Questions:
1) Have your expectations/fears/hopes/aspirations materialized throughout the course?
2) Have you reached what you wanted to be able to do/feel/learn by the end of this course?
3) How has the course impacted you as a person?
4) How did you experience the group process in the entire programme?
5) Did the education and project track impact your view on the role of the education in the world?

6) REFLECTION

Experiential questions:
    a. Can you describe your experience with reflection throughout this programme?
    b. Is there any particular moment of the reflection process that you thought was especially important to you?
        i. When in the reflection track did this moments occur?
        ii. What did you do in this moment?
        iii. Why did you do this?
        iv. Was anyone else involved in this reflection moment (other students or teachers)?
        v. How did you feel about this moment
    c. Is there any other moment that was important to you? (repeat sub-questions 1-5). Repeat again until there are no more salient moments.

Summative questions:
    d. Based on what we discussed, what would you say that reflection *is*?
    e. What do you think that reflection is *for?* What is the purpose of reflection?
    f. How do you understand *cognitive* reflection?
    g. How do you understand *phenomenological* reflection?
    h. How do you understand *relational* reflection?
    i. How do you understand *societal* reflection?

Exploring relationship to experiences

      j. Have your views on reflection changed during the course of this programme? If so, how and why did they change?

      k. Did any particular experiences in this programme contribute to your views on reflection?

      l. What are important things that you would recommend we keep in mind when designing reflection exercises in the future?

Concluding questions:

      a. Is there anything that I did not mention that you'd like to tell me about your experience with reflection?

      b. Do you have any questions for me?

Thank you for your participation and thank you for joining the CARE pilot programme!

APPENDIX 2

Reflection Diary prompts

It's time to draft your first learning reflection diary. There is no right or wrong answer for this assignment. It's about helping you to formulate pathways for connecting practice and reflection (dialogical theory of action). There is no word limit. We'd expect between 100 - 500 words for each question, but it's really up to you.

Describe	Describe a major learning event since the start of the CARE programme. This could be a single moment in time, or a blurry sequence of events. This could be a formal learning moment, or an informal, social moment. This could be an individual learning moment, or connected with the group work.
Analyze	Taking into account the learning goals you wanted to accomplish, what thoughts, actions and emotions have been triggered by this learning event?
Reflection	What have you learned from the experience? Why is this learning significant to you at the personal, academic and social level?
Theorizing	How did the experience match with your preconceived ideas, i.e. was the outcome expected or unexpected? Does it relate to any (formal) theories that you know?
Experimenting	Is there anything you would do or say now to change the outcome? What actions will you take in the future based on this learning?

Final reflection question: do you want to make any changes to your learning goals based on this experience?