Received: 9 December 2020 | Revised: 20 June 2021 | Accepted: 20 August 2021

DOI: 10.1002/jee.20430

JEE
Journal of Engineering Education

RESEARCH ARTICLE

Examining engineering students' perceptions of learner agency enactment in problem- and project-based learning using Q methodology

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Abstract

Background: Few studies have reported how students enact learner agency in a team setting or examined what elements of team settings students perceive as more supportive of their learning in problem- and project-based learning (PBL) processes.

Purpose: This study explores how engineering students perceive their enactment of learner agency, particularly which aspects of the PBL process they find most important.

Method: Thirty-nine students from two PBL civil engineering courses in Qatar participated in the study. Q methodology was chosen for both qualitative and quantitative data collection and analysis. A 40-item Q set based on a theoretical model of learner agency was used.

Results: Eight significantly different student viewpoints emerged from the Q methodological factor analysis, indicating a range of individual perceptions of learner agency. Intrapersonal dimensions were highlighted by three of the eight viewpoints, behavioral dimensions were underlined by seven viewpoints, and environmental dimensions were valued by all viewpoints.

Conclusion: While the results reveal a wide range of individual experiences with learner agency across the three dimensions, students addressed self-directed learning aspects both actively and passively, suggesting that many participants still value instructors' roles of providing direct instruction and authorized knowledge in PBL. The results highlight the need for more awareness of learner agency and more opportunities for students to enact learner agency by increasing PBL knowledge, skills, and efficacy. Q methodology can contribute to engineering education research by providing new theoretical and empirical insights into learners' subjective understanding of agency in a PBL setting as a complex system.

KEYWORDS
engineering students, learner agency, PBL, Q methodology, Qatar

1 | INTRODUCTION

1.1 | Background

Learner agency in higher education is gaining interest due to its close association with learner-centeredness, self-regulation, collaboration, and autonomy (Mercer, 2012). Learner agency, referring to students' will and capacity to act, occurs through the interplay between students' autonomous learning engagement in particular sociocultural contexts and the contextual factors that promote or constrain their capacities to act (Mercer, 2012). Positive connections have been reported between students' agentic learning engagement and their self-efficacy, metacognitive knowledge, learning skills, and academic performance (Bandura, 2006), motivation and satisfaction (Reeve & Tseng, 2011), appreciation of learning experiences and outcomes (Luo et al., 2019), critical thinking, engagement, and skills development (Lindgren & McDaniel, 2012), and professional identity development (Jääskelä et al., 2017). While the current literature focuses on individual learner agency (Du & Naji, 2021; Jääskelä et al., 2017; Mercer, 2011b, 2012), little is known about how students enact agency and employ resources in team settings. Bandura (2006) suggested that agency is both individual and collective; individual actors combine knowledge, skills, and resources to pursue common goals. While teamwork has been increasingly promoted in higher education, particularly in engineering education (Borrego et al., 2013), collective and individual learner agency in team settings still needs to be explored.

1.2 | Context of the study

1.2.1 | Societal and cultural context

Following Qatar's National Vision 2030 (General Secretariat for Development Planning, 2008) to move the country from an oil- and gas-dependent economy to a knowledge-based society, the State of Qatar encouraged all educational institutions to adopt pedagogical innovations to develop students' 21st-century skills (Said, 2016). Being a leading state university, Qatar University, in which the current study was conducted, must therefore develop pedagogy to support transformative and competency-oriented learning.

While many countries seek to increase diversity in engineering fields, which are disproportionately comprised of White men (Pawley, 2017), Qatar's context is unusual. Because of Qatar's societal wealth, many Qatari students, especially male students, are unmotivated to study, particularly STEM subjects, within K–12 education (Said, 2016). Fewer male students are motivated to persist in higher education (Khalifa et al., 2016). Thus, a gender imbalance exists in Qatar's higher education, with female students representing over 60% of the overall student population. In the College of Engineering, among the 3252 students registered in 2020–2021, 54.5% are female students and 45.5% are male students (26% Qatari and 74% non-Qatari). Under Qatar's policy, undergraduate program enrollment is divided by gender, and the civil engineering program only enrolls male students. Sixty-four (25%) of the 258 students in the program are Qatari, while 194 (75%) are non-Qatari. Under these circumstances, the College of Engineering seeks to produce qualified engineering graduates to satisfy the job market and promote Qatar's technology enhancement and sustainable development.

1.2.2 | A context of PBL implementation

Globally, engineering education programs are implementing problem- and/or project-based learning, driven by the need for new engineering competencies (Kolmos & de Graaff, 2014), graduates' lack of workplace readiness (Strobel & van Barneveld, 2009), and changing accreditation procedures (Kolmos, 2017). PBL is a recognized pedagogical choice (Helle et al., 2006; Hmelo-Silver, 2012) that addresses all desired accreditation learning outcomes (Felder & Brent, 2003) and encourages students to solve complex real-life problems through teamwork.

PBL can refer to either problem- or project-based learning. Problem-based learning is defined as "an instructional learner-centered approach that empowers learners to conduct research, integrates theory and practice, and applies knowledge and skills to develop a viable solution to a defined problem" (Savery, 2015, p. 7). Project-based learning

describes students working in teams to solve a problem within a set timeline, resulting in an end product (e.g., reports, designs) (Helle et al., 2006). Existing literature has attempted to distinguish PBL by types and models, generally focusing on problem-based learning (Jonassen, 2011; Mills & Treagust, 2003). The terms "problem-based learning" and "project-based learning" are inevitably connected, and diverse practices can be categorized under PBL (van Barneveld & Strobel, 2019). Kolmos and de Graaff (2014) suggested merging models to combine characteristics of "problems" and "projects," thus maximizing engineering students' learning and employability. Rather than distinguishing between problem-based and project-based learning, the current study uses PBL to refer to a pedagogical approach embracing three major elements, namely (1) using problems as the start of learning, (2) using projects to organize the learning process, and (3) learning in a teamwork setting (Kolmos & de Graaff, 2014).

While the current literature agrees that PBL is widely valuable for student learning (Helle et al., 2006; Hmelo-Silver, 2012; Prince & Felder, 2006; Strobel & van Barneveld, 2009; van Barneveld & Strobel, 2019), additional evidence from different educational, societal, and cultural contexts is needed to research PBL in engineering education (Jonassen, 2011; Kolmos, 2017; Savin-Baden, 2014; van Barneveld & Strobel, 2019).

In Qatar, PBL generally remains a new phenomenon, although PBL has been piloted in several courses in the civil engineering program since 2019. Before the pilot implementation, the instructors received training from PBL experts and collaboratively restructured their course designs. Following the PBL principles for engineering education suggested by Kolmos and de Graaff (2014), these courses merged project work with problem-based learning principles through the following practices: (1) students were encouraged to work on real-life problems; (2) team project work was the major course element, with lectures playing a supportive role; and (3) team project reports were assessed as the major PBL learning outcomes. Students were encouraged to form interest-based teams to maximize their autonomy and responsibility for their learning (Kolmos & de Graaff, 2014). The PBL implementation in these courses was informed by suggestions and best practices from relevant literature on PBL in civil and structuring engineering, such as Beagon et al. (2018) and Shekhar and Borrego (2017). Our previous works documented initial findings after implementing PBL in pilot courses, including students' improved adoption of deep learning approaches (Du et al., 2019) and positive changes in their views and practices of collaborative learning in team projects (Du et al., 2020). Nevertheless, the studies also identified gaps among collaboration styles (Du et al., 2020), such as students' continued reliance on instructors as the major authorized sources of knowledge (Du et al., 2019, 2020; Naji, Du, et al., 2020; Naji, Ebead, et al., 2020). These gaps may be attributed to students' lack of collaborative learning experiences and the historical roles of teachers in Arabic culture and tradition (Du et al., 2020).

1.3 | Study purpose

The present study uses a complexity theory lens to conceptualize learner agency, embracing learners' subjective feelings of their agency, behaviors, and interactions with their environment (for further elaboration, see the literature section). The major characteristics of PBL in engineering education, including problem identification, solution finding, teamwork, and collaboration on project reports, demand both individual and group learner agency. While abundant literature exists on PBL's effectiveness for students' satisfaction, motivation, attitudes, and outcomes (Helle et al., 2006; Kolmos, 2017; Savery, 2015), few studies have explored how engineering students empower their own learning processes by enacting learner agency. Even less is known about which specific elements of PBL students perceive as most significant to their learning. The current study addresses these gaps and is guided by the following research question: Which aspects of the PBL process do engineering students consider to be more important for their learner agency?

2 | BACKGROUND LITERATURE

This section conceptualizes learner agency using a complexity theory lens in education in Section 2.1. In Section 2.2, we then discuss a theoretical model of learner agency in a PBL team setting that includes three interrelated dimensions based on Bandura's model of individual agency (2008): The intrapersonal dimension (Section 2.2.1), the behavioral dimension (Section 2.2.2), and the environmental dimension (Section 2.2.3). The theoretical model serves as a starting point to the empirical exploration regarding which PBL components students assess as most important to

their agency as learners; to this end, Section 3 discusses research design and methodology, and Section 4 reports research outcomes.

2.1 | Conceptualizing learner agency

Learning is conceptualized as situated within ongoing changes and emerging through the interactions between learners and teachers; therefore, agency is central to learning (Larsen-Freeman, 2019; Mercer, 2011b, 2012). To achieve educational success, learners must exercise autonomy, responsibility, ownership, self-direction, and reflection. Agency, a fundamental characteristic of human behavior, is crucial to the complexity theory of understanding learning and has been interrogated from different theoretical standpoints. The most relevant perspectives of this concept for educational settings have highlighted the vital roles of individual cognition and social contexts in shaping agency (Eteläpelto et al., 2013). Bandura (2006) suggested that humans, by controlling thought processes, motivations, and actions, are proactive and creative rather than simply reactive. Other researchers have emphasized the inseparability of individual cognition and sociocultural context, highlighting a reciprocally interactive relationship between them (Archer, 2003; Billett, 2008; Eteläpelto et al., 2013).

This study applies a complexity theory lens to learning and education. The complexity theory of change and development is often applied in educational settings to highlight the need for self-organized, dynamic education systems that respond effectively to emerging societal changes (Morrison, 2008). According to Morrison (2008), this approach acknowledges that learning is nonlinear and complex, rather than a simple cause–effect process, and demonstrates the inseparable integration of the many factors influencing learning.

In a complexity-based curriculum, such as PBL, learning is seen as dynamic, emergent, open, relational, self-organized, and connected through the interactions among parties (Larsen-Freeman, 2019; Mercer, 2012; Morrison, 2008). Therefore, learning assessments should address creativity, collective knowledge, and students' responses to uncertainty and emergent changes rather than emphasizing standardized individual performance (Morrison, 2008).

Pedagogically, complexity theory challenges the traditional role of teachers as the masters of authorized knowledge, suggesting that they become co-constructers of meanings and co-creators of new knowledge by supporting students' teamwork on real-life problems (Fullan, 1989). In a complex learning environment, learners make active choices with autonomy rather than following a prescribed and programmed sequence (Mercer, 2012).

Therefore, following the literature, this study defines learner agency as a complex, dynamic system including three interrelated aspects: (1) learners' sense of agency (Mercer, 2011b, 2012), measured through their subjective perceptions of their agency in given contexts (Archer, 2003); (2) learners' agentic behavior (Mercer, 2011b, 2012), measured through their choices and enactment of agency (Billett, 2008); and (3) learners' interaction with their environment (i.e., teamwork, classroom), whether purposeful or unconscious, active or passive (Archer, 2003; Billett, 2008; Eteläpelto et al., 2013).

Under this definition, individual agency involves both subjective thinking and intrapersonal characteristics, including feelings, beliefs, and thoughts (Bandura, 2008) and autonomous, self-regulatory, and goal-oriented strategic learning behaviors (Bown, 2009; Gao, 2010). This definition also highlights the interplay among individual self-efficacy, motivation, and autonomy, and social context (Eteläpelto et al., 2013). The study embraces engineering students' perceptions of their will and power to learn and their determination and capacity to initiate, choose, regulate, take resources, act upon, and enrich their learning within the sociocultural context. Within a PBL team setting, an individual may also enact agency through collective action (Bandura, 2006), influencing the contents and conditions of learning and reshaping prevailing patterns of interaction with the environment (Eteläpelto et al., 2013).

Learner agency has been explored across several disciplines. The language learning field defines it as including both an individual's internal sense of agency, reflected in their subjective perceptions, and their agentic behaviors, observed through their participation in certain activities (Gao, 2010; Larsen-Freeman, 2019; Mercer, 2011b). Multiple studies focusing on preservice teachers defined agency as the ability to make free or independent choices, engage in autonomous actions, and exercise judgment in the interests of others and self (Campbell, 2012). In K–12 science education, critical science agency refers to how students view the world with a critical mindset and develop their understanding of and participation in physics and mathematics (Basu et al., 2008).

Several branches of engineering education research relate to agency, generally highlighting individual dimensions such as students' beliefs about their self-efficacy (Mamaril et al., 2016; Williams & George-Jackson, 2014), motivation (Godwin & Kirn, 2020; Mamaril et al., 2016), engineering identity development (Tonso, 2014), and academic persistence

(Godwin et al., 2016; Patrick et al., 2018). Similar to Basu et al. (2008), Godwin and Potvin (2017) defined agency as an individual's ability to shape the world through both their everyday actions (e.g., designing solutions using disciplinary knowledge) and their broader goals (e.g., pursuing an engineering career). Secules et al. (2018) also explored the role of self-regulation in agency development. However, both studies (Godwin & Potvin, 2017; Secules et al., 2018) focused on issues affecting minorities, drawing on case studies that followed a single student's trajectory during one stage of engineering study.

In their systematic review on professional identity in higher education, Trede et al. (2012) concluded that higher education prioritizes transmitting theoretical and formal knowledge over allowing students to exercise agentic actions and prepare for their professions. In particular, while higher education encourages collaborative learning, its professional development practices largely focus on individual professional socialization opportunities, for example, internships, with limited opportunities for students to exercise professional agency in a collaborative environment (Trede et al., 2012). Despite the acknowledged importance of agency, few studies exist on learner agency in higher education contexts; thus, more research is needed to explore university students' experiences and investigate how they exercise and apply learner agency in specific contexts (Jääskelä et al., 2017). This research gap served as the initial motivation for the present study.

2.2 | Examining learner agency enactment in a PBL team setting

Bandura's (2008) exploration of the complexity of human agency, which highlighted both the social cognition of individuals and their sociocultural contexts, identified three fundamental, interrelated dimensions of agency: intrapersonal (cognitive, affective, and motivational), behavioral, and environmental. These dimensions also correspond to the "control parameters" Mercer (2011b) described as guiding learning trajectories and influencing learners' development of agency. Furthermore, Mercer (2011b) suggested that this complex system consists of multiple interrelated, interacting components. Hence, context (including micro- and macro-level structures and artifacts) can be understood as an integrated part of a complex learning system (Mercer, 2012) rather than something that exists externally (Jääskelä et al., 2017).

In their review of effectiveness in engineering education, Borrego et al. (2013) identified professional learning outcomes from team projects, including teamwork, design, communication skills, innovation and creativity, industry-related experiences, self-directed learning, efficacy, and motivation (p. 480). These outcomes align with the three dimensions of agency Bandura suggested; thus, they can be seen as important elements of learner agency enactment. The learning principles in PBL engineering education, which derive from a constructivist approach to learning (Helle et al., 2006; Kolmos, 2017; Savery, 2015), align with the previous definition of learner agency from research on language learning (Larsen-Freeman, 2019; Mercer, 2011b, 2012). Complexity theory allows us to relate the components of the engineering education team setting to the three dimensions of learner agency Bandura (2008) identified. Therefore, the present study aims to examine which aspects of the PBL process engineering students perceive as more important for their learner agency. Figure 1 illustrates a model of learner agency in a PBL team with three interrelated dimensions (derived from Bandura, 2008), which will be discussed later in the section.

2.2.1 | The intrapersonal dimension

Bandura noted that an individual's belief in their efficacy is the key agentic resource supporting personal development and change, affecting how individuals might perceive (actively or passively) their expectations, goals, anticipations, and chosen actions (2008, p. 38). The intrapersonal dimension of learner agency includes cognitive, motivational, and affective factors. Within this dimension, essential components for learner agency include belief, efficacy, motivation, interest, and attitude, with one of the most critical being the learner's belief system (Gao, 2010; Mercer, 2011a, 2011b). This belief system is complex and includes beliefs about self-concept, self-confidence, self-efficacy, and identity (Mercer, 2011a; Ruohotie-Lyhty & Moate, 2016). Learners' beliefs about how they can achieve goals through strategic actions can powerfully impact their actual learning behaviors and performances (Hatlevik et al., 2018). These beliefs may manifest as expressions of agency and serve as sources of agency, enabling individuals to show greater interest in learning, achieve higher outcomes, and persist through challenges (Jääskelä et al., 2017). However, a learner's lack of

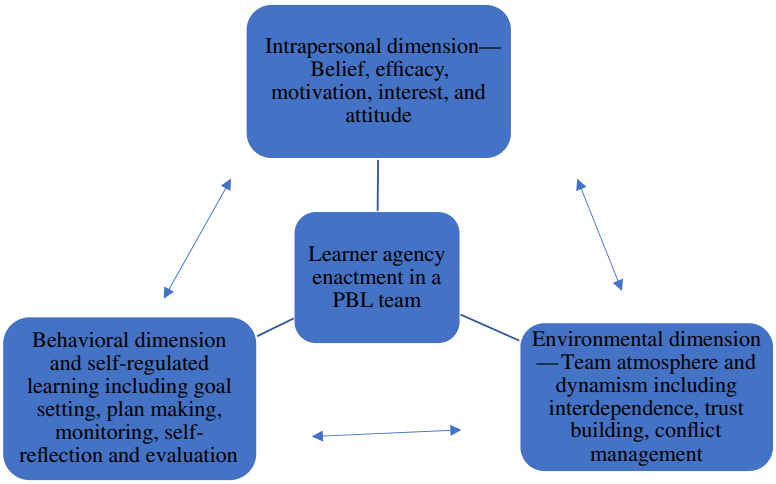

FIGURE 1 A model of learner agency in a problem- and project-based learning (PBL) team consisting of three interrelated dimensions. *Source*: Derived from Bandura (2008) [Color figure can be viewed at wileyonlinelibrary.com]

belief in their abilities or the presence of negative beliefs may negatively impact their engagement. In a PBL team setting, a student's agency is strengthened if they believe that PBL is an appropriate method to support their learning and prepare them for professional competence (Naji, Du, et al., 2020; Naji, Ebead, et al., 2020), that they can gain the PBL-relevant knowledge and skills to achieve the targeted learning goals (Naji, Du, et al., 2020; Naji, Ebead, et al., 2020), that they can overcome challenges in the learning process, and that they are becoming a professional (e.g., an engineer) (Godwin & Potvin, 2017).

Another crucial factor in learner agency, motivation, that is, students' orientation, enjoyment, and engagement in learning activities, is driven by an internal aspiration that moves students toward success when they enjoy educational activities (Ryan & Deci, 2000). Motivation, both intrinsic and extrinsic, plays a central role in guiding learners to either exercise agency and choose certain paths of action or select passivity (Mercer, 2012). Learning motivation is a fluid process that emerges from the interaction among a student's internal characteristics and external contexts. Components that affect learner agency include interest in and attitude toward the learning process and content. PBL has been well documented to help learners improve their motivation to learn (Helle et al., 2006), including in engineering studies, as learners appreciate how PBL highlights the connections between theory and practice (Beagon et al., 2018; Kolmos, 2017; Shekhar & Borrego, 2017).

2.2.2 | The behavioral dimension

According to Bandura (2008), self-regulation, which refers to learners' active metacognitive, motivational, and emotional participation in the learning process, is another key feature of learner agency. From a socio-cognitive perspective, agency is closely associated with individuals' self-processes, such as forethought, intentionality, monitoring, and self-reflection (Bandura, 2006). In line with this view, Zimmerman (1990) and Zimmerman and Kitsantas (2005) observed that self-regulated learners are proactive in planning, setting goals, organizing, self-monitoring, strategically seeking to improve knowledge and skills, self-reflecting, and self-evaluating. In particular, self-regulated learners employ strategies "directed at the acquisition of information or skills that involve agency, purpose, and instrumentality perceptions by learners" (Zimmerman, 1990, p. 5).

Self-regulated learning is also a key concept in problem-based learning (Zhao & Zheng, 2014) and a major outcome of learning through projects and teamwork (Borrego et al., 2013). Previous studies reported that students take initiative in PBL settings by selecting, structuring, and creating optimal learning environments in project teams (Du et al., 2020; Zhao & Zheng, 2014). Effective self-regulatory learners are aware of themselves as active agents and exercise their agency through various strategies (such as learning from prior experiences, adjusting plans and processes related to goals, and seeking multiple sources of information, among others) to actively shape and construct their learning experiences and motivational and affective responses (Bown, 2009). In particular, agentic students collectively identify

learning goals and detect problems on which to work independently (Zhao & Zheng, 2014). They are proactive, making plans to organize their project work and adjusting their approaches as contextual factors change. They also solve issues independently, explore multiple information sources, and seek various ways to progress their projects. Collectively, learners with agency adapt to a project's competing needs in the context—for example, responding to the time management capabilities and pressure of a team project to adjust goals and plans as needed (Borrego et al., 2013; Du et al., 2020). In a team setting, agentic individual learners participate collaboratively, contributing initiatives, ideas, and constructive feedback while challenging each other. However, individuals with little or no PBL experience may have few resources to support other students, thus tend to prioritize their own tasks and grades (Du & Naji, 2021).

2.2.3 | The environmental dimension

Bandura (2008) suggested that learners are not merely reactive products impacted by one-sided external pressure; rather, they are "prime players in the co-evolution process" (p. 36) and "create intricate styles of behavior necessary to thrive in complex social systems" (p. 37). In other words, individuals have opportunities to purposefully exercise control over their personal development and life circumstances through deliberative ideas, creative thoughts, and forethoughtful self-regulation.

In higher education literature, several contextual characteristics have been identified as critical to encouraging learner agency, including a supportive environment, feedback from instructors, and reciprocal and dialogic relations between instructors and students (Jääskelä et al., 2017) and among students (Lipponen & Kumpulainen, 2011). Individual experiences and sense-making are subjective; learners vary in how they interpret their relationships to others, their relationships to the community, and the ways their context (i.e., team, class, institution) supports agency enaction.

The team setting can be an important factor in the environmental dimension of learner agency. Recent studies have identified characteristics of proactive teams and agentic individuals in team settings. Borrego et al. (2013) identified five constructs for team effectiveness, namely (1) the inclusion of all members' ideas and contributions and the avoidance of social loafing; (2) interdependence among members enhanced through complex project work, task division strategies, collaborative contribution processes, feedback, and group-based grades; (3) conflict management through common interests and goals, time management, and enthusiasm for co-constructing new knowledge with peers and instructors (Morrison, 2008); (4) efforts to build trust and team dynamics; and (5) teamwork process adjustments through self-organization activities including process monitoring, self-evaluation, and adaptation. Members of healthy teams support and challenge each other to achieve their full potential as learners (Borrego et al., 2013). However, recent studies on team dynamics in a PBL setting reported that poorly performing teams tend to rely on instructors and provided materials as the major sources of authorized information (Du et al., 2019; Zhao & Zheng, 2014), and simply divide tasks among members with little effort to synergize (Du et al., 2020).

By highlighting learners' agentic abilities rather than reverting to traditional learning conditions, complexity theory creates a social cognition framework grounded in triadic reciprocal determination within which people exercise individual and collective agency through the interplay of intrapersonal, behavioral, and environmental influences. Guided by this three-dimensional model on learner agency, the study examines engineering students' perceptions and experiences of their learner agency in a PBL team setting. In particular, this study explores which PBL components students assess as most important to their agency as learners.

3 | RESEARCH DESIGN

3.1 | Research context and participants

The study occurred in two civil engineering courses. Due to the COVID-19 pandemic, the university offered two fall 2020 course delivery options: full-scale online via Blackboard Collaborate (Blackboard, 2021), WebEx (WebEx, 2021), or MS Teams (MS Teams, 2021); or a blended mode including both online and socially distanced face-to-face sessions. All students were given PBL information based on the three characteristics elaborated in the introduction.

Course 1, "Environmental Engineering," targeted third- and fourth-year civil engineering students. The course instructor had never implemented PBL before, and most students had little or no PBL experience. The 15-week online

course consisted of 50-min sessions that met three times a week. The instructor allocated one weekly session for lectures and two weekly sessions to discuss PBL work with students via the Blackboard Collaborate platform (Blackboard, 2021). Students were divided into groups using the built-in "group feature," which allowed the instructor to move freely among groups. Students were asked to provide an action plan for transforming the university campus into a green "sustainable" campus. The project was divided into several phases to monitor students' progress. First, students provided a literature review related to the proposed problem. Next, they established a benchmark for global and regional sustainable campuses. Students then performed a comprehensive sustainability assessment focusing on water, air, land, and noise pollution as well as hazardous and solid waste management. Assessment reporting met the Global Reporting Initiative (GRI) standard developed by the Global Sustainability Standards Board (GSSB) (Global Reporting Initiative, 2021a, 2021b). Finally, students developed a sustainable action plan (SAP) that included strategies with specific achievable actions and outcomes (Center for Sustainable Healthcare, n.d.). Course assessment, based entirely on project work, included a group-based report (60% of the total course grade), oral presentation (5%), project-related lab (10%), and project-related individual exam (25%).

Course 2, "Selected Topics in Construction Engineering & Management," targeted third- and fourth-year engineering students. While the instructor had implemented PBL in the course twice before, most students had little or no PBL experience. The 15-week blended course included 75-min sessions three times a week. The instructor allocated two weekly sessions to discuss prerecorded lecture contents and PBL work with students via the WebEx platform (WebEx, 2021). For one weekly session, students worked in teams (six teams with five students each) in a socially distanced, secured room while the instructor and teacher's assistant circulated to offer direct support. The instructor suggested a project theme of building information modeling (BIM); teams then chose particular aspects to focus on, identifying real-life problems in Qatar. The project centered on teamwork, scheduling optimization techniques, overall resource management utilizing BIM authoring tools such as Autodesk Revit 2019, and BIM 4D and 5D applications using Autodesk Navisworks 2019 (Navisworks, 2019; Revit, 2019). Course assessment, based entirely on project work, included a group-based report (60% of the total course grade), oral presentation (10%), and project-related individual final exam (30%).

The study was approved by the college and university ethical committee. Students from both courses (course 1: $n = 25$; course 2: $n = 22$) were invited to voluntarily participate. In accordance with university ethical regulations, students received a consent form outlining the study's purpose, description, consequences, and ethical principles. Thirty-nine of the 47 students participated. Fifteen students had previous PBL experience, while 24 were beginners. Students' ages ranged from 20 to 27; however, only two were older than 23 (24 and 27), which explains the mean age of 22.4 years. The study was conducted in English, the language of study used in the program.

3.2 | Q methodology

The present study aims to explore learner agency through a complexity lens, capturing unobservable and uncertain aspects of human subjectivity. Most studies on agency employ qualitative data generation, such as narrative interviews and observation (Du et al., 2021; Mercer, 2012). Despite the limitations of analyzing the complex interactions among different components of agency, recent research tends to analyze agency quantitatively using Likert scale surveys (Jääskelä et al., 2017). To benefit from both qualitative and quantitative features while investigating participants' subjective understanding of their agency, we chose an inherently mixed method (Ramlo, 2016) as a fitting approach for this study. Q methodology (henceforth Q), invented almost 90 years ago by William Stephenson, a British physicist-psychologist, has been widely employed in social science research to investigate individual beliefs, perceptions, and views (Brown, 2019; McKeown & Thomas, 2013; Watts & Stenner, 2012). Despite its long history as a robust, systematic methodology, the approach only recently experienced increased attention in educational research (Lundberg et al., 2020). Researchers have suggested that a Q study could investigate learners' social and emotional development of resilience, agency, and self-direction. Nevertheless, among the 74 published studies identified in a systematic review of the use of Q in educational research, none addressed learner or teacher agency (Lundberg et al., 2020). However, Q has proven useful to explore the complexity of belief systems and subjective perceptions of educational issues (Lundberg, 2020), as it investigates individual system aspects in relation to one another rather than in isolation.

Within engineering education research, Q methodology is still a relatively novel approach (Desing & Kajfez, 2020). Nevertheless, it has been used to study engineering PhD students' career paths (Kajfez et al., 2014), identify nanotechnology competencies for engineering students (Liu et al., 2015), investigate student perceptions of learning in

cooperative education (Ehlert, 2020), and assess a construction engineering technology program (Ramlo, 2016), to name but a few. For the present study, Q was selected as the best-fitting methodology to engage engineering students in a reflective ranking process and, thus, explore the importance of different PBL aspects to their learner agency.

3.2.1 | Research procedure

This study's data collection and analysis followed a standard Q methodological procedure, as summarized by Lundberg et al. (2020). Six steps are outlined: (1) concourse development, (2) Q set construction, (3) participant Q sorting, (4) post-sorting activities, (5) Q factor analysis, and (6) factor interpretation.

Concourse development

The first step in Q methodological research demands extensive field knowledge and reflection on the contextual nature of subjectivity (Brown, 2019). A multitude of sources is usually applied to collect statements about the topic. In the technical Q language, the universe of these statements is called a *concourse* (Stephenson, 1953). In the present study, the concourse came from previous research described in the theoretical sections of this paper and our own experience of implementing PBL. The first author has 18 years of experience researching PBL and supporting international PBL implementation; the third and fourth authors have, respectively, 3 years and 1 year of experience researching and implementing PBL in their own classes, which are the context of the current study. Because learner agency in PBL is conceptualized as a complex system, no initial long list of statements was created. Instead, the model described in the following section served as a structuring and selection tool.

Q set construction

The Q set construction process used the theoretical basis of learner agency as a system consisting of three interrelated dimensions as a deductive starting point. As shown in Table 1, all statements are assigned to one of the three dimensions in the model of learner agency in a PBL setting derived from Bandura (2008). Despite these categorizations, the statements are also understood to be interrelated and cross-dimensional.

To formulate the statements in an understandable and communicable way, the second author, who is an experienced Q researcher, facilitated an inductive process with the research team. This process resulted in a 40-item Q set. The statements are written in the present tense, as the data were collected while the courses were still in progress. To validate the data collection instrument, two teaching assistants, both recent graduates supporting the current courses, sorted the items and provided valuable feedback on their phrasing. Both pilot participants were familiar with the context, including the course content, PBL method, students, and institutional culture. Minor adjustments were made at this stage to clarify statements, but no items were deleted or added.

Participant Q sorting

Data were collected using QMethod Software (Lutfallah & Buchanan, 2019). Three online sessions, in total lasting 3 h, were offered; students from the courses conducted Q sorting with online individual support from four of the co-authors.

TABLE 1 From concourse development to Q set

Dimension of learner agency in a PBL team	Statement number
(P) Intrapersonal dimension: Individual belief, efficacy, motivation, interest, and attitude[a]	7 statements: 1, 2, 16, 17, 23, 24, 25
(B) Behavioral dimension and self-regulated learning: Goal setting, plan making, monitoring, self-reflection and evaluation, and information sources[b]	16 statements: 3, 4, 5, 9, 11, 15, 18, 22, 26, 27, 28, 30, 31, 32, 35, 40
(E) Environmental dimension: Team atmosphere and dynamism, team formation, trust building, team health, conflict and time management, interdependence of group members[c]	17 statements: 6, 7, 8, 10, 12, 13, 14, 19, 20, 21, 29, 33, 34, 36, 37, 38, 39

Abbreviation: PBL, problem- and project-based learning.

[a]Bandura (2006, 2008); Gao (2010); Mercer (2011a, 2012).

[b]Bandura (2006, 2008); Du et al. (2020); Mercer (2011a, 2012); Zhao and Zheng (2014); Zimmerman (1990); Zimmerman and Kitsantas (2005).

[c]Bandura (2006, 2008); Borrego et al. (2013); Du et al. (2020).

Participants were instructed to provide demographic information (see Section 3.1) and then rank-order the 40 statements according to the importance of the PBL learning experience aspects they represented. Through a "drag and drop" online sorting tool, each statement was assigned a hierarchical position from "less important" (−5) to "rather important" (+5) in a forced-choice, quasi-normal, and symmetrical distribution grid (see Figure 2 for a screenshot of the empty grid). Because Q methodological items are investigated through relative rather than absolute terms, the participants were expected to constantly compare statements. Individuals applied their subjective views of their learning experience in a PBL team; this process resulted in a single holistic configuration generated through the described Q sorting technique.

Post-sorting activity

Additional qualitative information about participants' decisions was collected through a post-sorting survey with open-ended questions. Participants were asked to elaborate on the reasoning behind their choices of the two statements they ranked as the most important and the two they ranked as the least important. They were also asked whether they would like to address any missing or additional aspects of their PBL experiences. To investigate students' overall attitudes toward PBL, a further question was asked: "How would you compare an individual learning-focused approach with a PBL approach to this course?"

Q factor analysis

For Q-sort correlations and inverted factor analysis, raw data were imported from QMethod Software into KADE, a Q analysis tool (Banasick, 2019). Centroid analysis and Varimax rotation were used to condense the data. The final factor structure was determined by comparing different factor solutions. Here, generally applied statistical criteria, such as an eigenvalue greater than 1.00, explained variance, and at least two significantly loading participants per factor (McKeown & Thomas, 2013; Watts & Stenner, 2012) were merely used as guidelines (Brown, 1978). More important was the factors' theoretical significance. The researchers discussed the participants' responses until they reached a final agreement that led to the most informative factor solution. The selected eight-factor solution explains 60% of the study variance. Eight factors are above the standard for Q studies; for example, in the systematic review of Q publications in educational research (Lundberg et al., 2020), most Q studies retained between two and four factors. However, in this study, no significant factor intercorrelations were found. This confirms the value of the eight-factor solution described and discussed in this paper.

Of the 39 valid respondents, 32 significantly loaded on one of the eight factors. These responses were used to create a shared factor array (a weighted average of values per item within one factor). Five sorts significantly loaded on a factor, but always negatively; as eight factors exist, single negative sorts were excluded rather than splitting the factors. Two confounded sorts were also excluded. An overview of the values assigned to individual statements per factor is

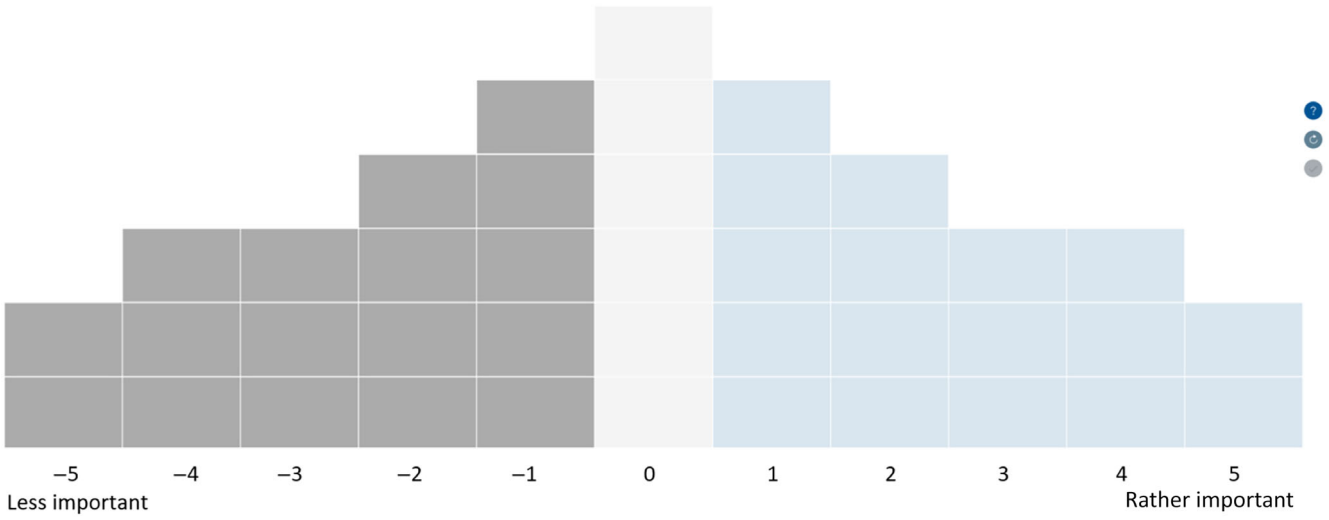

FIGURE 2 Empty Q-sort distribution in QMethod used for this study. Participants were asked to individually assign each of the 40 statements (see Table 2) a slot in this grid from "less important" on the left to "rather important" on the right [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 2 Factor Q values for statements sorted by level of consensus (from the most consensus to the most disagreement)

#	Dim.	Statement	V1	V2	V3	V4	V5	V6	V7	V8	Z-score variance
39	(E)	My team members have compromised to reach consensus	0	−1	−1	0	−1	−1	0	1	0.129
28	(B)	My team has sought for assistance from the program or college in case of need	−3D	−2	−1	−1	0	0	0	1	0.259
21	(E)	My team has helped each other in case of anyone lacking behind	2	0	1	−1	−1	−1	2	3	0.332
10	(E)	My team has made efforts on time management	3	2	0	1	−4D	2	0	2	0.478
35	(B)	My team has used some members' prior PBL experiences in our current project work	−4D	−1	1	0	−5D	−1	−2	−1	0.485
32	(B)	My team has modified our project process by needs	0	−2D	2	3	1	−4D	0	0	0.518
36	(E)	I have prioritized the tasks assigned to me in the teamwork	1	0	−1	2	−1	3	5D*	1	0.573
33	(E)	I have felt comfortable to express my opinions in my team	1	−1	0	−3D	1	0	2	5D*	0.601
9	(B)	My team has relied on materials provided by course instructor to ensure our work has been on track	−2	1	1	−3	−2	2	4	0	0.605
27	(B)	My team has tried to handle challenges on our own before we consulted our course instructor	2	0	0	−2	4	−2	2	−1	0.613
40	(B)	My team has regularly checked up on how the plans have been followed	2	1	1	1	−2	3	4	−3	0.616
4	(B)	My team has ensured all of us have reached the course expected learning outcomes	−1	−1	2	0	−2	0	−2	5D	0.629
19	(E)	I have participated in the decision-making in the team project process	5	4	−1	5	3	4	1	−1	0.63
13	(E)	My team has coped with conflicts constructively	0	−2	−2	2	−3	1	1	4D	0.641
17	(P)	I have developed a sense of becoming a professional in PBL	1	3	0	4	1	−1	1	−3	0.644
6	(E)	I have taken initiatives in the team project process	1	1	−4D*	0	3	0	3	−1	0.655
22	(B)	My team has searched for diverse sources of materials to work on the project	4	0	0	−4D	1	−2	−1	1	0.686
11	(B)	My team has regularly reflected on our progress	0	−1	4	−4	0	−3	0	2	0.718
16	(P)	I have become more motivated to learning in a PBL way	0	1	3	3	2	−1	−4D*	2	0.754
24	(P)	In PBL the instructor has no longer been the major source of authorized knowledge	0	−3	−3	0	2	1	0	−5	0.78

(Continues)

TABLE 2 (Continued)

#	Dim.	Statement	V1	V2	V3	V4	V5	V6	V7	V8	Z-score variance
30	(B)	My team has received the problem from the instructor	−3	3	0	−1	1	1	−5D*	−2	0.83
5	(B)	My team has regularly discussed with other teams to learn from their progress	−4	−2	−3	1	−4	−2	2	0	0.832
1	(P)	PBL has been appropriate for maximizing my learning	−3D	5	1	1	3	2	−1D	4	0.848
14	(E)	My team members have challenged each other to learn more	−1	−4	−2	4D*	0	1	−2	−2	0.853
15	(B)	My team has consulted multiple sources of expertise other than the course instructor	3	−4D	3	0	2	−2	−2	1	0.873
3	(B)	My team has set up common learning goals	−2	−3	5	1	−3	1	−1	3	0.893
23	(P)	I have enjoyed trying new ways to learn	−1	1	1	−2	2	−5	−5	0	0.907
18	(B)	My team has asked for direct instructions from our course instructor	1	1	5D	−1	1	−5D	3	−1	0.909
7	(E)	I have made efforts for better performance regarding both team and individual grades	2	−1	2	−2	4	−1	5	1	0.919
12	(E)	My team has met regularly to work together	3	4	−1	−2	−3	−3	3	3	0.925
20	(E)	My team has divided tasks among individuals	1	2	3	−3	0	5D*	1	−1	0.949
8	(E)	I have provided other team members with constructive feedback	−1	−3	−2	−5	−2	3D*	−3	−4	0.958
29	(E)	My team has been formed by our common interests	4D	2D	−3	−1	−5	0	−3	−2	1.027
31	(B)	I have used my prior PBL experiences in the current course	−5D*	2	−2	2	−1	−4	−1	−3	1.031
34	(E)	My team has made efforts to build trust	−2	−5	4D	−5	−1	1	−1	2	1.153
37	(E)	My team has selected a leader to coordinate our project work	−2	3	2	1	−1	5D*	1	−4D	1.388
25	(P)	I had the knowledge about PBL at the course start	−5	5D*	−5	−1D	0	−3	−1	0	1.423
2	(P)	I have had the skills to work in PBL	−1	0	−5	3	5D*	0	−3	−2	1.461
38	(E)	I have engaged myself to the team project to benefit my career readiness	5	0	−4	2	5	4	−4	0	1.531
26	(B)	My team has chosen the project topics on our own	−1	−5	−1	5D	0	2	1	−5	1.822

Note: D indicates statements that significantly differed from the viewpoints ($p < .05$). An asterisk (*) indicates significance at $p < .01$.
Abbreviations: B, behavioral dimension; Dim., theoretical dimension; E, environmental dimension; P, intrapersonal dimension; PBL, problem- and project-based learning; V, viewpoint.

given in Table 2. The statements are listed from those with the most consensus (smallest Z-score variance) to those with the most disagreement across the factors (largest Z-score variance).

Q factor interpretation

Factor interpretation in Q is highly qualitative and aims to provide a holistic overview of participant responses based on the factor arrays. The abductive and iterative process usually starts with a within-factor interpretation supported by participants' demographic information and post-sorting responses. To clarify differences among factors, factor descriptions are enriched with an across-factor interpretation. This interpretation is facilitated by Table 2.

4 | RESULTS

The following sections describe the factors emerging from the Q analysis. As factors represent participants' own perceptions of agency enactment, they are called *viewpoints* in their interpreted form "to accentuate their predominantly subjective character" (Lundberg, 2020, p. 25). Each viewpoint is described using its quantitative attributes and is followed by a narrative summary based on factor interpretation. Each statement's number is indicated in brackets, together with its assigned value in the specific factor array. Each statement is referred to by its item number and rated on a scale from −5 to +5; for example, "#19/5" refers to statement 19 with the value of 5. To highlight statements on which the viewpoints significantly differed, "D" is added after the value number to represent "distinguishing statements" ($p < .05$) or D* to represent "significantly distinguishing statements" ($p < .01$).

Table 3 reports an overview of results summarized by participants' demographic data, including class, group, age, and prior PBL experience, related to their lower-ranked statements across all three dimensions of learner agency.

In the following sections, we report the results of each viewpoint related to the model.

4.1 | Viewpoint 1: Team matters

Viewpoint 1 participants ($n = 7$, explaining 11% of the opinion variance), who had no prior PBL experience, highlighted various statements addressing both individual and collective aspects of the environmental dimension of learner agency.

TABLE 3 Summary of viewpoint results

V	*N*	Expl. variance	Course: *n* (team constellation)	Age range	Prior PBL experience	Highest ranked #	Lowest ranked #
V1	7	11%	1:3 (cross 2 teams) 2:4 (cross 2 teams)	21–23	Yes: 0 No: 7	19 (E) 38 (E)	31D* (B) 25 (B)
V2	5	10%	1:3 (cross 2 teams) 2:2 (same team)	20–24	Yes: 3 No: 2	1 (I) 25D* (I)	26 (B) 34 (E)
V3	4	9%	1:2 (cross 2 teams) 2:2 (same team)	20–24	Yes: 1 No: 3	18D (B) 3 (B)	25 (I) 2 (I)
V4	4	7%	1:3 (cross 2 teams) 2:1	21–24	Yes: 3 No: 1	19 (E) 26D (B)	8 (E) 34 (E)
V5	2	7%	1:1 2:1	22–23	Yes: 1 No: 1	2D* (I) 38 (E)	29 (E) 35D (B)
V6	3	6%	1:1 2:2 (cross 2 teams)	21–22	Yes: 1 No: 2	20D* (E) 37D* (E)	23 (I) 18D (B)
V7	4	5%	1:0 2:4 (cross 2 teams)	22–27	Yes: 2 No: 2	7 (E) 36D* (E)	30D* (B) 23 (I)
V8	3	5%	1:1 2:2 (cross 2 teams)	22–26	Yes: 1 No: 2	33D* (E) 4D (B)	26 (B) 24 (I)

Abbreviations: #, number of statement; B, behavioral dimension; D, distinguishing statement at $p < .05$; D*, distinguishing statement at $p < .01$; E, environmental dimension; Expl. variance, explained variance; I, intrapersonal dimension; *n*, number of sig. loading sorts; PBL, problem- and project-based learning; V, viewpoint.

They ranked participating in decision-making and engaging in the team project learning process to prepare for career readiness (#19/5; #38/5) as essential to their learning experience. Also highlighted was the role common interests played in team formation (#29/4D). This view is further reflected in participants' post-survey responses, which confirmed that forming teams based on common interests was significant because "freedom of group choosing is an important part of PBL." Following this focus on team formation, Viewpoint 1 also highlights the importance of time management efforts (#10/3). Most of these participants emphasized their efforts to meet regularly to ensure the team project was on track; one wrote, "following regularly on how the task is progressing helps in time management ...," while another explained, "time was the most important thing to manage when it is the first time for me to experience this teaching style."

These students also highlighted two statements from the behavioral dimension: seeking diverse sources for project work (#22/4) and consulting multiple experts apart from the course instructor (#15/3). Most participants confirmed these statements in their post-survey responses; they explained that they were unsure whether the course content prepared them sufficiently to conduct PBL, so they utilized the team to collect more materials.

Participants from Viewpoint 1 ranked intrapersonal statements as less important to their PBL work. In particular, they did not believe prior PBL experience (#31/−5D*) (distinguishing this viewpoint from others), knowledge about PBL at the beginning of the course (#25/−5), or the belief in PBL's appropriateness to maximize learning (#1/−3D) offered important sources of learner agency during their PBL experience. They also reported two statements addressing the behavioral dimension of learner agency as less important: assistance from the program or college in case of need (#28/−3D) and opportunities to learn from other teams (#5/−4). These rankings were due to participants' lack of prior experience in PBL, which limited their available resources, as stated in their post-survey responses.

In sum, Viewpoint 1 participants, who lacked prior PBL experiences, highlighted environmental dimensions relating to both individual and collective resources for the team; however, their individual beliefs and efficacy remained limited, suggesting that prior PBL experience may help students develop interpersonal dimensions and the ability to utilize multiple information sources as part of the behavioral dimension. These students also suggested in post-survey responses that project teams without prior experience could be offered more supportive information on PBL early in the project.

4.2 | Viewpoint 2: Following instructors' suggestions to feel safe

Five students were associated with Viewpoint 2 ($n = 5$, explaining 10% of the opinion variance). Unlike respondents associated with Viewpoint 1, participants in this category emphasized the importance of intrapersonal dimension sources of learner agency. Compared with other viewpoints, Viewpoint 2 participants rated PBL knowledge at the beginning of the course (#25/5D*) as the most important; the statement was related to their prior PBL experience (three students) or to clear PBL instruction given at the start of the course (two students). Both students without prior PBL experience mentioned in their post-sorting survey the helpfulness of receiving clear information on PBL. Viewpoint 2 also valued their beliefs in the appropriateness of PBL as a method to maximize learning (#1/5); as one student wrote, "it will help me on further courses such as senior project design." Another student provided another perspective: "PBL teaches us that there is no limit for learning and it is not a typical learning process depending on course content and the instructor."

Viewpoint 2 students addressed both high- and low-ranked statements in the behavioral dimension. Compared with other viewpoints, Viewpoint 2's choices generally reflect a reliance on instructors, which is reflected in their high ranking of the statement on receiving the problem from the instructor (#30/3). This choice explains their low ranking of statements on student teams choosing project topics (#26/−5) and consulting multiple sources of expertise beyond the course instructor (#15/−4D). Viewpoint 2's reliance on instructors is further emphasized in students' post-survey responses; as one wrote, "following instructors' suggestions will make us feel safe on the track." Students with previous PBL experience also positively reported their ability to apply prior experiences to the team-based self-regulated learning of this project (#31/2).

Within the environmental dimension, Viewpoint 2 students reported both high and low rankings. On the one hand, these students valued regular team meetings (#12/4) (collective aspects in a team); as one wrote, "in my opinion teamwork was the key of the project success and since it's a large project then the group must cooperate." On the other hand, Viewpoint 2 students gave several environmental dimension statements with low rankings. While they considered team trust-building efforts to be less important (#34/−5) (collective aspects in a team), the explanations they offered for this decision seemed positive; as one wrote, "trust isn't an issue since we already chose the group members, and we are familiar with each other." Other low-ranked statements included team members challenging each other to learn more (#14/−4), setting common learning goals (#3/−3), and reaching team consensus via compromise (#39/−1).

The course instructors provided a general topic for the class, under which each team could select a narrower topic. The participants from Viewpoint 2, spanning four different teams from both courses, believed that their teams mainly followed the instructors' guidance and relied on the goals and resources provided. As one wrote, "the instructor is still the main source for us and the material we needed was mostly from experts."

Generally, Viewpoint 2 participants placed high intrapersonal value on efficacy in PBL and beliefs about PBL appropriateness. Behaviorally, they relied on instructors' opinions to drive the PBL process; therefore, they exhibited less self-regulated learning. Teamwise, these participants chose their friends as team members, which resulted in fewer team-building efforts. Prior PBL experience offered them useful resources at the intrapersonal level but was less useful in the behavioral and environmental dimensions.

4.3 | Viewpoint 3: Direct instruction is needed

Viewpoint 3 participants ($n = 4$, explaining 9% of the opinion variance), from two PBL teams (one from each course), prioritized the importance of environmental dimension statements, including the creation of common learning goals (#3/5) and team efforts to build trust (#34/4D). As one participant explained in the post-sorting survey, "we always need to build trust between all members of the group so it can be easy to work together."

Within the behavioral dimension, similarly to Viewpoint 2, Viewpoint 3 participants ranked asking for direct instructions from course instructors highly (#18/5D), possibly because three of these four participants had no prior PBL experience. As one student wrote, "we need the full guide from our instructor ... we did not know about PBL previously, we only learned it in this course." These participants also emphasized the importance of regular reflection on team progress (#11/4) and consulting multiple sources of expertise beyond the course instructor (#15/3). One participant commented in the post-sorting survey that "we try to search for many sources to reach our goals and to have enough information."

Additionally, these participants ranked intrapersonal dimension statements on individual knowledge about PBL (#25/−5) and skills relating to PBL (#2/−5) as the least important aspects. Unlike Viewpoint 1, Viewpoint 3 gave low rankings to two environmental dimension statements highlighting individual aspects: taking initiative (#6/−4D*) and engaging in the team project to increase career readiness (#38/−4). For three participants, these choices were related to a lack of prior PBL experience; one wrote, "we did not know about PBL previously, we only learned it in this course." The student with PBL experience wrote, "because I had skills in other courses, so I did not have difficulty in processing in this course."

In sum, Viewpoint 3 participants, who, like Viewpoint 1 participants, generally had no prior PBL experience, ranked highly the team-related aspects of the environmental dimension and gave the lowest rankings to the interpersonal dimension. Unlike Viewpoint 1, Viewpoint 3 also gave low rankings to statements that focused on individual aspects within a team.

4.4 | Viewpoint 4: Agency from all dimensions

Viewpoint 4 ($n = 4$, explaining 7% of the opinion variance) reported positively on statements across all three dimensions. Within the intrapersonal dimension, participants holding this viewpoint also stressed the importance of motivation to learn (#16/3). Within the behavioral dimension, they reported the importance of choosing the project on their own (#26/5D) and modifying the project process as needs change (#32/3). This may be because three of these students had prior PBL experience, all of whom confirmed their positive attitude toward PBL in the post-sorting survey. Within the environmental dimension, like Viewpoint 1, Viewpoint 4 highly ranked participating in the team project decision-making (#33/5). Compared with other viewpoints, these students emphasized two statements of collective team aspects within the environmental dimension: the importance of team members challenging each other to learn more (#14/4D*) and developing a shared sense of becoming professionals (#17/4). As one wrote, "work with a group is good ... I can communicate with other people when I graduate."

In line with Viewpoint 2, but unlike Viewpoints 1 and 3, Viewpoint 4 generally gave low rankings to behavioral dimension statements, including those related to searching for diverse source materials (#22/−4D), reflecting regularly on team progress (#11/−4), relying on materials provided by course instructors (#9/−3) and environmental dimension statements, including those related to building trust (#34/−5), providing other team members with constructive feedback (#8/−5), dividing tasks among individuals (#20/−3), and feeling comfortable expressing opinions in a team (#33/−3D). These rankings also related to students' prior experiences, as confirmed in the post-sorting survey.

Viewpoint 4, with prior PBL experience, covered the highest number of statements; these students highly valued resources from all three dimensions, although they also reported low rankings across the behavioral and environmental dimensions. While they significantly prioritized some features of team performance, such as team members challenging each other, these participants also undervalued other team-related aspects, such as providing team members with constructive feedback.

4.5 | Viewpoint 5: PBL skills are useful for my career

One participant from each class was associated with Viewpoint 5 ($n = 2$, explaining 7% of the opinion variance); one was new to PBL, while the other had previous PBL experience. Like Viewpoint 4, Viewpoint 5 covers all three dimensions. Within the intrapersonal dimension, these students significantly valued PBL skills for their learning experience in the course (#2/5D*) compared with other viewpoints and valued enjoying new ways to learn (#23/2). Within the behavioral dimension, in stark contrast to Viewpoint 2, Viewpoint 5 participants also considered the instructor to no longer be the major source of authorized knowledge in PBL learning (#24/2).

Within the environmental dimension, participants highly ranked three statements relating to individual aspects of the team, including engaging in the team project for career readiness (#38/5) (similar to Viewpoint 1) and taking initiative (#6/3) (unlike Viewpoint 3); in the post-survey response, the participant new to PBL wrote, "I love searching and exploring solutions by myself," which supported them in developing skills for PBL. The other student wrote that "it helped me to improve in contacting with others easily and as a senior student it really helped me to be a team player." Unlike those representing Viewpoint 4, Viewpoint 5 participants also appreciated their teams' ability to handle challenges themselves before consulting instructors (#27/4). In the post-survey responses, they further conveyed the belief that considering how to maximize student learning was most important when implementing PBL.

Generally, the statements Viewpoint 5 participants viewed as less important were environmental dimension statements involving collective aspects in teams; these responses were similar to those from Viewpoints 2 and 4, although they were given for different reasons. The lowest-ranked aspects of Viewpoint 5 included team formation based on common interests (#29/−5) (unlike Viewpoint 1), using some members' prior PBL experience (#35/−5D) (unlike Viewpoint 3), time management (#10/−4D) (unlike Viewpoint 1), meeting regularly to work together (#12/−3) (unlike Viewpoint 2), and coping with conflicts constructively (#13/−3). These choices were further confirmed by the post-sorting survey responses. As the PBL beginner wrote, "this is our first time hearing about PBL, so we don't have any experience and we don't know other students who knew about it before." The student with PBL experience wrote, "it was least important to choose the team according to our common sense because it is important to learn how to deal with anyone."

Other statements these students ranked low in importance were within the behavioral dimension, including regular discussion with other teams (#5/−4) (congruent with Viewpoint 1) and setting common learning goals (#3/−3) (congruent with Viewpoint 2). As the PBL beginner wrote about time management, "We don't know each other and never worked with each other before, we tried to meet but of course some of our group members were not interested." One participant also explained that the online mode was challenging for teams: "it is not easy to meet with my team in a regular way during the pandemic in a safe way."

In sum, Viewpoint 5 participants, one with prior PBL experience and one without, agreed on the importance of PBL skills and the contribution of such skills to their future anticipated careers. The focus on future career readiness is also reflected through other choices, such as the stated belief that students should be able to work in teams that include anyone, as they would in a workplace.

4.6 | Viewpoint 6: Collective agency in team

Viewpoint 6 ($n = 3$, explaining 6% of the opinion variance), with three participants from three groups across the two courses, mainly highlighted collective aspects of team environmental dimensions as sources of learner agency. Compared with other viewpoints, Viewpoint 6 considered selecting a leader to coordinate project work (#37/5D*) and dividing tasks among team members (#20/5D*) as highly important. Unlike Viewpoint 4, Viewpoint 6 also highly valued the role of providing constructive feedback to other team members (#8/3D*). These views are related to students' experiences of positive team management; as one student wrote, "my teams were very helpful in achieving the PBL outcomes and helping each other as well." Another student explained, "time management is the most essential in our work and a team leader is needed to make the work organized."

Statements ranked low by Viewpoint 6 crossed all three dimensions. Within the intrapersonal dimension, enjoying trying new ways to learn was considered less important (#23/−5). On the behavioral dimension, Viewpoint 6 ranked asking for direct instruction least important (#18/−5D). An explanation emerged in the post-sorting survey: "We have relied on ourselves in PBL work, and this gives us convenience in our work and enhance our work to done in the future in the correct way." Similar to Viewpoints 2, 4, and 5, participants in this category also gave low rankings to statements related to self-regulation in teams, such as modifying project processes according to needs (#32/−4D). Within the environmental dimension, like Viewpoint 4 but unlike Viewpoint 5, Viewpoint 6 placed less importance on meeting regularly to work together (#12/−3) (this is similar to Viewpoint 5 but differs from Viewpoint 2) and teams' ability to handle challenges on their own before consulting instructors (#27/−2). Two participants with minimal experience with PBL before this course attributed these choices to their lack of prior experience.

Compared with other viewpoints, Viewpoint 6 highlighted the collective aspects of team environmental dimensions as sources of learner agency, focusing on how to manage the teamwork process. They also underlined their self-reliance and independence in refraining from asking for direct instruction from the instructor.

4.7 | Viewpoint 7: Ensuring individual performance in a team

Viewpoint 7 ($n = 4$, explaining 5% of the opinion variance) positively reported statements in two dimensions. Within the environmental dimension, compared with the other viewpoints, Viewpoint 7 highlighted the importance of individual aspects of the team, including tasks assigned to individual members (#36/5D*), individual efforts for better team and individual grades (#7/5), and initiative-taking (#6/3) (like Viewpoint 5 but unlike Viewpoint 3). In the post-sorting survey, explaining why they highly valued taking initiative (#6), one student wrote that PBL is similar to "what people from the industry are exposed to."

Within the behavioral dimension, Viewpoint 7 also highly ranked discussing work with other teams (#5/2) (unlike Viewpoints 1 and 5), relying on materials provided by instructors (#9/4) (unlike Viewpoint 4), and regularly checking on team plans (#40/4). Post-sorting surveys confirmed these choices and provided elaboration, as one student explained the importance of discussing work with other teams (#9): "It is easier to interact with classmates rather than an instructor. It is easier to discuss the material with a person who is as new as I am to the material." Another student explained the importance of checking up on team plans (#40): "we have to finish the submissions on time and we try everything we know before asking the instructors."

Lower-ranked statements from Viewpoint 7 were related to all three dimensions. Within the intrapersonal dimension, these participants did not see PBL as improving their motivation to learn (#16/−4D*) (unlike Viewpoint 3). They also gave low rankings to enjoying trying new ways to learn (#23/−5) (in contrast to Viewpoint 5). Within the behavioral dimension, Viewpoint 7 respondents valued receiving the problem from the instructor (#30/−5D*) (unlike Viewpoint 2). As one student explained, "it is important to learn from the instructor but not everything." They also did not see the team projects as substantially helping to ensure all students achieved the course outcomes (#4/−2). Two of the four students, both with prior PBL experience, confirmed these choices, relating them to their preference for "traditional" methods. One wrote, "I prefer other methods of learning," while the other elaborated, "The traditional learning method is not 'bad' and has been used since forever. Personally, I don't prefer PBL courses over the traditional classes." The other two students in Viewpoint 7, both of whom had little or no experience with PBL, reflected positively on their first PBL experience in the post-sorting survey. One participant explained that their choices were mainly related to a lack of PBL experience; the other claimed a preference for individual learning over teamwork.

Within the environmental dimension, Viewpoint 7 gave a low ranking to engaging individually on the team to improve career readiness (#38/−4) (in line with Viewpoint 3 but unlike Viewpoints 1 and 5).

In sum, Viewpoint 7 participants mainly valued statements from the environmental dimension and gave lower rankings to values from the interpersonal dimension. They focused on ensuring each individual was engaged in their own tasks and earned high grades in a team setting.

4.8 | Viewpoint 8: All members shall achieve the course outcomes

Positively reported statements by Viewpoint 8 ($n = 3$, explaining 5% of the opinion variance) participants were mainly related to behavioral and environmental dimensions. Within the behavioral dimension, they believed teams should

ensure all members achieve the course outcomes (#4/5D), which is in contrast to Viewpoint 7; as one participant wrote, "by achieving the learning outcomes we will ensure that our work is completed in high quality; hence, the grade will be high." Within the environmental dimension, these participants also prioritized statements related to collective aspects in teams. In stark contrast to Viewpoint 4, this viewpoint emphasized the importance of feeling comfortable expressing individual opinions in the team (#33/5D*); one student explained, "I think that to have a good understanding between the group members is the most important part to have a useful experience." Other highly ranked statements included coping with conflicts constructively (#13/4D) (in contrast to Viewpoint 5) and helping someone who is lagging behind (#21/3) (in contrast to Viewpoints 4, 5, and 6). One student explained, "My team has always dealt with challenges faced in PBL. We met regularly and discussed together; hence we have overcome the challenges."

Lower-ranked statements by Viewpoint 8 participants crossed all dimensions. Within the intrapersonal dimension, students placed less importance on developing a sense of becoming an engineer through PBL (#17/−3) (in contrast to Viewpoint 4); the two participants attributed this to their limited PBL experience. Within the behavioral dimension, compared with other viewpoints, Viewpoint 8 viewed the opportunity for teams to choose their own project topics as unimportant (#26/−5) (congruent with Viewpoint 2 but in contrast to Viewpoint 4). As two participants with little or no PBL experience explained, this was because the instructor suggested the overall topic. One reflected, "it does not make difference if problem is selected by instructor or identified by students." Participants from Viewpoint 8 also placed little importance on the instructors no longer being the major source of authorized knowledge (#24/−5) (in line with Viewpoint 5); one explained, "I disagree with this statement because we learn more from the instructor." In addition, they did not prioritize regular checking up on plans (#40/−3) (unlike Viewpoint 7). Within the environmental dimension, these students gave low rankings to selecting a leader to coordinate project work (#37/−4D) (significantly different from Viewpoint 6). This choice may relate to participants' statements in post-survey responses that selecting a team leader was unnecessary because "we have a very good group that each one does his best in each part."

In sum, Viewpoint 8 highlighted the importance of each team member achieving course outcomes and feeling comfortable expressing individual opinions in the team. Meanwhile, these students demonstrated passive agency regarding self-regulated learning, devaluing the change in the instructor's role from a knowledge transmitter to a learning facilitator.

4.9 | Areas of consensus

Although the Q methodological analysis found no single statement with statistically significant consensus across all viewpoints, the participants agreed on some aspects (Table 2). For example, perhaps because of their limited PBL experience, they were largely uncertain about the importance of team members compromising to reach consensus (#39) and teams seeking assistance from the program or college in case of need (#28).

Most viewpoints also highlighted the importance of team efforts to manage time effectively (#10). This was confirmed by qualitative data from the post-sorting survey responses, particularly from students without prior PBL experience.

The most disagreed-with statement was "my team has chosen the project topics on our own" (#26). Analysis of post-sorting survey responses suggests that participants may have been confused about the meaning of "choosing the topics themselves." The PBL course instructors provided a broad scope of project topics/themes, within which students could narrow down and identify particular project topics. The resulting confusion led to students' disagreement with this statement. The Q-sort analysis also revealed disagreement regarding the importance of PBL-related knowledge (#25) and skills (#2), which appears to be primarily related to students' prior PBL experience or lack thereof.

The post-survey responses (in which 38 of the 39 participants responded to all questions) generally confirmed the Q sorting analysis results. The responses revealed a positive attitude toward and experience with PBL; all but four students supported PBL as an appropriate teaching and learning method. Of the four who preferred traditional teaching and learning processes, three represented Viewpoint 7, and two of these had prior PBL experience. The fourth, a PBL beginner representing Viewpoint 5, reported strong PBL skills despite lack of experience but stated a preference for individual learning over team-based work. This may be due to poor team communication, whereby the participant "had to work hard to cover for other students who were lacking." Therefore, they preferred individual learning because "you only have yourself to count on, which really suits me better. But in the PBL approach, we have to work as a team, in my case, we were a group of strangers that never met each other and formed their group last minute by default, so it was really tough for me."

5 | DISCUSSION

This section discusses the study results before providing implications, methodological reflections, limitations, and further perspectives.

5.1 | The results in relation to the theoretical model

The study identified eight significantly different viewpoints regarding engineering students' perceptions of their learner agency in a PBL course; these viewpoints emerged from Q factor analysis and explained 60% of the total study variance. Despite the homogeneity in age (most participants were aged 20–23), gender (all male), ethnic background (all Arab), and major (all enrolled in the same civil engineering program), the study participants reported a wide range of perceptions of how PBL experiences affected their learner agency. The research question asked what aspects of learner agency students perceive as most important to their learner agency in PBL, and the Q study results revealed similarities and differences in participants' individual viewpoints on this question. These viewpoints correspond to the three interrelated dimensions of the operational model of learner agency in PBL. This section discusses each of these dimensions (intrapersonal, behavioral, and environmental), which were suggested by Bandura (2008).

First, three of the eight viewpoints prioritized the intrapersonal (cognitive, motivational, and affective) dimension of learner agency (Bandura, 2006) in PBL. In particular, participants holding Viewpoints 2, 4, and 5 highly valued their belief in PBL as an appropriate learning method (Ruohotie-Lyhty & Moate, 2016), possession of necessary PBL knowledge and skills (Naji, Du, et al., 2020; Naji, Ebead, et al., 2020), development of transformative beliefs about teaching and learning roles (Fullan, 1989; Morrison, 2008), and sense of identity building (Mercer, 2012) to become a professional (engineer) (Godwin et al., 2016). Viewpoint 4 also highlighted the importance of improved motivation (Larsen-Freeman, 2019; Ryan & Deci, 2000) in PBL settings, and Viewpoint 5 emphasized the intrapersonal aspect of learning. These results align with previously described benefits of PBL (Beagon et al., 2018; Kolmos, 2017; Naji, Du, et al., 2020; Naji, Ebead, et al., 2020; Shekhar & Borrego, 2017), as the literature has suggested that cognition, beliefs, motivation, and efficacy are vital in enabling students to become agentic learners in PBL.

Second, self-regulated learning was addressed by seven of the eight viewpoints (all except Viewpoint 6), which aligns with its important role in the literature. Self-organization is a key feature of complexity theory (Fullan, 1989; Morrison, 2008), and self-regulation is considered a core aspect of learner agency in a complex system (Bandura, 2006; Gao, 2010; Larsen-Freeman, 2019; Mercer, 2011a, 2011b, 2012). Nevertheless, participants in the current study focused on various aspects when discussing how their agency related to self-regulated learning. According to Zimmerman (1990) and Zimmerman and Kitsantas (2005), the essential elements of self-regulation interact with each other, collectively influencing learners' choices, decisions, and allocations of their agentic resources. Among the essential components of self-regulated learning suggested by Zimmerman (1990) and Zimmerman and Kitsantas (2005), goal setting was emphasized by Viewpoint 3, plan monitoring by Viewpoints 4 and 7, and reflection and evaluation by Viewpoints 3 and 8. However, only Viewpoints 2, 3, and 4 mentioned the importance of activating prior experience (Bandura, 2006) in PBL.

Students also demonstrated their enactment of agency through self-regulated learning both actively and passively. Previous studies have highlighted the importance of teachers' changing roles from knowledge transmitters to learning facilitators when implementing PBL (de Graaff & Kolmos, 2003; Helle et al., 2006; Kolmos & de Graaff, 2014; Shekhar & Borrego, 2017). However, studies in Asian contexts documented (through qualitative data such as interviews) that PBL student beginners, often believing instructors were still the major sources of authorized knowledge, struggled to accept this change (Du et al., 2019, 2020; Zhao & Zheng, 2014). The current study reported mixed results, describing students' learner agency both proactively and passively. For example, Viewpoint 1 valued finding diverse project sources and consulting multiple experts beyond the course instructor, Viewpoint 4 valued formulating problems independently, and Viewpoints 5 and 8 valued considering the instructor to no longer be the major source of authorized knowledge in PBL. However, Viewpoints 2 and 7 valued receiving problems from instructors, and Viewpoints 2 and 3 valued direct instruction from the instructor. Further, while Viewpoints 1, 5, and 8 highlighted students' agency in exploring multiple learning sources, Viewpoints 3 and 7 relied on the instructor to provide the problem and project scope and as the major source of knowledge and learning.

Generally, the results suggest that the learners participating in this study have not comprehensively adopted a self-directed learning framework in their program context. This may be specifically related to the online

implementation of PBL, in which students are less self-organized for teamwork due to feelings of insecurity (Naji, Du, et al., 2020; Naji, Ebead, et al., 2020). In addition, teacher-dominant beliefs still prevail among students, particularly impacting individuals with minimal PBL experience in their choice-taking and decision-making in team settings (Du et al., 2019).

Third, all eight viewpoints emphasized the importance of the environmental dimension, highlighting the learners' ability to interact with environmental sources of agency in team settings. Six of the eight viewpoints (1, 4, 5, 6, 7, and 8) highlighted individual aspects of agency regarding their choices, efforts, and actions in PBL teams, such as taking initiative, participating in decision-making, providing constructive feedback, and handling individual tasks to ensure team performance (Borrego et al., 2013; Du et al., 2020). Seven viewpoints (all except Viewpoint 7) prioritized the importance of a range of collective team aspects. The results reflected the constructs of team effectiveness, including team atmosphere, health, norms, and dynamics, summarized by Borrego et al. (2013) as well as the team effectiveness features identified in studies conducted in Asian contexts (Du & Naji, 2021; Naji, Du, et al., 2020; Naji, Ebead, et al., 2020). These aspects included forming teams based on common interests (Viewpoint 1), meeting regularly to work together (Viewpoint 2), attempting to build trust (Viewpoint 3), challenging each other to learn and develop a shared sense of becoming professionals (Viewpoint 4), appreciating team members' ability to handle challenges themselves before consulting instructors (Viewpoint 5), dividing tasks among individuals and selecting a leader to coordinate the project teamwork (Viewpoint 6), and constructively coping with conflict (Viewpoint 8).

Generally, all viewpoints either relatively clearly used the intrapersonal dimension (Viewpoints 2, 3, 4) or did not use it (Viewpoints 1, 3, 6, 7, 8). The behavioral and environmental dimensions are more compound, as most viewpoints demonstrated overlapping opinions, illustrating the complexity of learner agency. Only Viewpoints 2 and 3 highlighted the behavioral dimension as an important source of agency. Viewpoint 1 ranked aspects in the environmental dimension considerably high, while Viewpoint 2 placed a lower value on these aspects.

The post-sorting survey responses further suggest significant variation among participants' perspectives. Few significant demographic characteristics were identified in this study; all Viewpoint 1 participants had little or no experience with PBL, and the three Viewpoint 7 participants were all from course 2. Generally, those with minimal PBL experience expressed concerns about team functioning and tended to spend more time and effort on team building, which is congruent with previous results about students' first PBL experiences (Du & Naji, 2021; Naji, Du, et al., 2020; Naji, Ebead, et al., 2020).

The range of perspectives indicates that the enactment of learner agency in PBL is a complex process. It requires individual cognition, motivation, efficacy, attitude (Bandura, 2008), engagement, PBL knowledge and skills, and self-regulated learning in a team-based environment as well as both individual and group efforts to ensure team effectiveness (Borrego et al., 2013).

5.2 | Pedagogical implications

The results of this study, which provide evidence on how individual students perceive their enactment of learner agency in a PBL team setting, have several pedagogical implications. To maximize the benefits of PBL, a mechanism must be developed to support the desired outcomes; both students and teachers must take proactive steps to support students' learning. As a practical implication, individual learners should develop self-awareness of the components of agency to empower themselves to build effective learning strategies (Mercer, 2011b, 2012). The lowest-ranked statements (see Table 2) can be addressed in future PBL implementation, potentially facilitating opportunities for students to enact learner agency in new ways. More importantly, educators should support students' individual and collective empowerment by providing resources to promote their efficacy, motivation, and affect in PBL (Mercer, 2011b, 2012; Reeve & Tseng, 2011) and their individual and collective self-regulation skills (Bown, 2009; Gao, 2010; Larsen-Freeman, 2019).

Further, students' continued belief that instructors play an important role in PBL settings by providing direct instruction and offering a feeling of safety reflects a linear-focused, non-complexity approach to pedagogy and curriculum (Morrison, 2008); this approach contradicts the PBL philosophy, which highlights students' agency. This result suggests that changing learning beliefs takes time (Mercer, 2011b) and deserves pedagogical attention when instructors implement PBL. It is, therefore, highly recommended that PBL instructors clarify the importance of the changing roles of both teachers and learners to better support student learning independence and agency enactment.

Previous studies identified time management as a common struggle in project teamwork (Borrego et al., 2013); recent studies (Du et al., 2019, 2020) also identified PBL teams as struggling with time management. These findings were confirmed in the current study, implying that PBL instructors should emphasize skills and reminders to help students improve their time management skills. This focus may be particularly vital when students have minimal experience with PBL; instructors can support these students by providing clear instruction on PBL, facilitating their development of PBL knowledge and skills, and encouraging them to build efficacy for a self-independent approach to PBL (Du et al., 2020).

5.3 | Methodological reflection

Earlier studies have used narrative inquiry and ethnographic approaches (Mercer, 2011b, 2012) with small participant samples to explore the enactment of learner agency. By using Q methodology, we identified various perspectives among a larger group. The selected approach also provided space to investigate similarities and differences among these various viewpoints. Through a post-sorting survey, participants were able to verify and elaborate on their choices regarding the most and least important statements. This underscores Q's potential to promote critical reflection (Lundberg, 2020; Lundberg et al., 2020) and confirms its ability to structure interviews to enhance the credibility of results and provide in-depth information (Brown & Militello, 2016).

The only option for conducting Q research during the COVID–19 pandemic was to use an online software tool, which may have reduced the benefit of the communicative nature of Q sorting. Although we tried to mitigate this by providing online support while participants were responding to the Q-sort, some technological software challenges were encountered. Participants may have been misled by the darker color on the left side of the grid (Figure 1), a technicality that produced an unnecessary dualism in the choice-making process. Furthermore, there was no option to add instructions above the grid (Figure 1).

Overall, the study was exploratory in nature. The Q methodology inherently creates factors that generalize among similarly-minded people related to the topic at hand. While statistical generalizability of the Q methodological results is not an aim, future research with other social groups, particularly female participants, should further investigate the relevant topics. Although the results of this study are most relevant to its particular setting, they provide valuable insights into the subjective perception of learner agency in other PBL settings.

5.4 | Limitations of the study

This study has several general limitations in addition to the Q methodology limitations described above. First, by focusing on learner agency, the study may appear to have undervalued the role of other related concepts such as motivation and identity, which are relevant to complexity theory and important in engineering education. Although we highlight learner agency in this particular study, we also acknowledge the importance of other concepts. Second, while the response rate was high (83% of the targeted population) and the number of participants ($n = 39$) was above the mean for recent Q methodological studies in educational research (Lundberg et al., 2020), the viewpoints of nonparticipating students and students from other courses, programs, or modes of teaching (i.e., not online) may be different and could have significant implications. Nevertheless, due to the study's eight-factor solution, it is highly likely that additional students would agree with their peers on the described viewpoints. Third, although the post-survey responses confirmed most of the relevant aspects of the Q set data, additional statements reflecting on further aspects of learner agency may exist, particularly in different course contexts. Fourth, the study applied a nonparticipatory research approach; adding alternative methods such as interviews may offer deeper insights into participants' perceptions of PBL and its effects.

5.5 | Future perspectives

The results of the present study suggest future research directions. First, it is worth investigating learner agency from a longitudinal perspective to document how it develops over time (Mercer, 2012) and how it interacts with learners' efficacy, motivation, and sense of professional identity, or with other key concepts in engineering

education. Future research might also examine the interaction among components of learner agency in team settings, including how individual and collective components interact and which team characteristics may support individuals' ability to self-regulate within teams, which is rarely addressed in the current literature (Zhao & Zheng, 2014). It is also worth comparing the results of the current study with studies using the same methodology that include participants from other social groups, such as students with significant PBL experience, female students, students from other engineering programs, or students from other societal and cultural contexts. Furthermore, this study context underlined certain types of PBL characteristics, such as using problems as a starting point of learning and using projects and teamwork to organize the learning process. Future studies may examine students' learner agency sources in PBL contexts with different characteristics, such as contexts that focus on end products as an outcome of project-based learning (Mills & Treagust, 2003).

6 | CONCLUSION

The present study explored how engineering students perceive which aspects of the PBL process are the most important for their enactment of learner agency. The proposed conceptualization of learner agency as a complex system enables us to understand and analyze how agency is perceived and enacted by learners in a PBL setting through three interrelated dimensions: intrapersonal, behavioral, and environmental. Q methodology, which highlights the intentionality and subjectivity of human agency, was chosen to conduct inherently mixed-methods research. During the Q sorting, 39 students from two senior civil engineering courses individually ranked the importance of statements according to their subjective views on their learning experiences in PBL teams. A diverse range of individual learner agency was identified, with eight significantly different viewpoints emerging from the Q methodological factor analysis. While the results reveal a wide range of individual experiences with learner agency across the three dimensions, self-directed learning aspects were described both actively and passively, suggesting many of the participants still value the instructor's role in providing direct instruction and authorized knowledge in a PBL process. The study also revealed that while a PBL setting highlights learner agentic engagement, students, particularly those new to PBL, may still believe instructors are the major source of authorized knowledge, which may hinder their ability to take agentic actions. These results have pedagogical implications that both educators and students need to be aware of. Educators can support learner agency by increasing students' PBL knowledge, skills, and efficacy to help them navigate individual and collective self-directed learning. Ultimately, Q methodology provided new theoretical and empirical insights into learners' subjective understanding of learner agency in a PBL setting; thus, it can contribute to the continued growth and evolution of engineering education research.

ACKNOWLEDGMENT

Open access funding enabled and organized by Projekt DEAL.

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How to cite this article: Du, X., Lundberg, A., Ayari, M. A., Naji, K. K., & Hawari, A. (2022). Examining engineering students' perceptions of learner agency enactment in problem- and project-based learning using Q methodology. *Journal of Engineering Education*, *111*(1), 111–136. https://doi.org/10.1002/jee.20430