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Examining emic viewpoints on a pedagogical development program's long-term effects using Q methodology

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ABSTRACT

To examine the long-term effects of pedagogical development, the study explored 56 Chinese university instructors' viewpoints on their professional agency in implementing new pedagogical practices following a PBL program in Denmark. Q methodology was supplemented by a post-sorting survey and post-analysis interviews. An eight-factor solution emerged, indicating a high variation in participants' subjective experiences of PBL implementation. Their perceived sources for agency enactment are both internal and external, crossing three phases in practice – readiness, implementation, and prospects. Despite suggesting positive long-term PD effects, the study also illustrates how university instructors' agency enactment is constrained by contextual aspects, including a lack of surrounding acceptance and support. Practical implementations how PD programs may support long-term teacher learning through agency development are provided.

1. Introduction

University teachers are experts in various disciplines, but not necessarily in pedagogy. Therefore, they need support to explore and practice alternative and innovative pedagogical methods that maximize student learning (Saroyan & Trigwell, 2015). Often also called university instructors, they are offered a wide range of pedagogical development (PD) activities, which the literature may interchangeably refer to as faculty/staff/academic/professional development activities. While most current PD activity initiatives focus on supporting the enhancement of constructivism-based and student-centered learning, many recent studies have evaluated these activities based on university instructors' satisfaction, perceptions, and resulting changed attitudes and pedagogical beliefs (Assen, Meijers, Otting, & Poell, 2016; Chalmers & Gardiner, 2015; Saroyan & Trigwell, 2015). Although a general increase in interest and engagement has been identified in terms of university instructors' participation in PD activities, researchers have also reported instructors' resistance to change their attitudes towards student-centered learning and develop new related pedagogical beliefs (Assen et al., 2016; Pecore, 2013). Further, a disconnect was identified between instructors' self-perceived change of pedagogical attitudes and conceptions and their actual practice (Assen et al., 2016; Bickerstaff & Cormier, 2015; Pecore, 2013). Thus, research on the long-term effects of PD activities remains inconclusive and deserves additional attention, particularly regarding how university instructors change their actual practices by implementing new pedagogies learned from PD activities (Assen et al., 2016; Chalmers & Gardiner, 2015; Saroyan & Trigwell, 2015).

How teachers develop professional learning as an outcome of PD activities is a complex question demanding multiple dimensions of change, including intrapersonal perspectives like attitude, motivation, affection, knowledge, beliefs, self-efficacy, and readiness to change practices, and perspectives of interactions with peers, students, and environments in the actual implementation of new pedagogical practices (Garner & Kaplan, 2021; Opfer & Pedder, 2011). Previous studies have shown that the long-term effects of PD activities, including the extent to which instructors adopt new pedagogical practices because of this learning, strongly relate to institutional factors such as facilities, leadership, and policy support (Campbell & O'Meara, 2014; Van Schalkwyk, Leibowitz, Herman, & Farmer, 2015). While much research still adopts a linear, cause-effect, and process-product approach to evaluating the effects of PD, assuming that teachers automatically learn from and can implement what is taught, alternative approaches from a complexity perspective are highly recommended, embracing the

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teacher-learning characteristics of non-linear, individually variable, contextually bonded and culturally sensitive (Garner & Kaplan, 2021; Opfer & Pedder, 2011; Russ, Sherin, & Sherin, 2016). Thus, to explore the rich, situative nature of teacher learning, the long-term effects of PD programs should be evaluated as part of a complex dynamic system of teacher learning, as Garner and Kaplan (2021) propose, including multiple interrelated aspects such as intra- and interpersonal characteristics and interactions between teachers and their environments.

To self-organize learning in such a complex system, instructors must adopt stances and make choices and decisions, thereby enacting their professional agency. University teachers' professional agency, often called teacher agency, refers to their power to act, make choices and decisions, influence their work, and take stances (Vähäsantanen, 2015). This is critical in the context of educational innovation and reform; it not only affects what, how, when, where, and for how long a teacher may use various practices in the classroom, thereby shaping implementation practices, but also promotes student engagement and impacts student learning outcomes (Garner & Kaplan, 2021; Opfer & Pedder, 2011; Russ et al., 2016; Vähäsantanen, Paloniemi, Räikkönen, & Hökkä, 2020). While increasing research has focused on teacher agency development in K12, the professional agency of university instructors, particularly regarding pedagogical change, remains rarely studied, demanding additional research (Vähäsantanen; 2015; Vähäsantanen et al., 2020).

The current study aims to examine the long-term effects of teacher learning from a PD program. Following an institutional agreement between the China Scholarship Council (CSC) and Aalborg University, Denmark, the CSC sponsored 70 Chinese science, technology, engineering, and mathematics (STEM) instructors (in two cohorts – 2017-2018 and 2018-2019, respectively) to participate in a 6-month-long program organized at Aalborg University, Denmark. The PD program supported participants in implementing student-centered learning methodologies such as problem and project-based learning (PBL), a pedagogical approach that has been well-adopted in STEM higher education internationally (Kolmos & De Graaff, 2014). While PBL can be defined and practiced diversely, the PD program was designed and organized encompassing three major PBL elements, namely 1) using problems to spark learning, 2) using projects to organize the learning process, and 3) learning in a teamwork setting (Kolmos & De Graaff, 2014) to enable the participants to experience PBL as learners. Our previous research from the first cohort in this program reported positive results regarding participants' meaningful learning about PBL by experiencing PBL as learners, improved critical reflection for transformative learning (Du, Kolmos et al., 2020), and changed pedagogical beliefs and intended practices towards a learner-centered mode (Du, Spliid et al., 2020). Nevertheless, the studies also found that some participants maintained their beliefs about themselves as major authorized sources of knowledge for students. Such beliefs, which can be attributed to the institutional policy and cultural ideology of being a teacher in China, limited instructors' intention and readiness to change their pedagogical practices to implement PBL (Du, Kolmos et al., 2020; Du, Spliid et al., 2020). Therefore, the current study follows up on the previous studies to further evaluate the PD program's long-term effects.

This study explores Chinese STEM instructors' subjective experiences of individual and collective agency regarding choice- and decision-making in their PBL implementation practices after participating in the PBL-based PD program in Denmark. Individual and collective agency are characteristically subjective, situative, and interpretative (Vähäsantanen, 2015; Vähäsantanen et al., 2020), aligning with the views that teacher learning as a dynamic complex system is highly contextualized (Garner & Kaplan, 2021; Opfer & Pedder, 2011; Russ et al., 2016). To highlight instructors' subjective perceptions of their agency, the current study used Q methodology (henceforth Q) to collect and analyze data both quantitatively and qualitatively (Brown, 2019). This approach is considered useful to explore the complexity of belief systems and subjective perceptions of educational issues; it investigates individual aspects of such systems related to one another rather than in isolation (Irie, Ryan, & Mercer, 2018). We adopted Q to explore subjective teacher learning experiences focusing on individual and collective professional agency as the long-term outcome of PD activities, thus contributing to research on the long-term effects of PD, professional agency as the core of teacher learning, and Q in educational research. To adapt a mixed-method research approach, Q methodology's quantitative analysis to explain the qualitative data was enriched with semi-structured interviews with eight selected participants.

2. Professional agency in a context of pedagogical change

2.1. Conceptualizing professional agency

The study is embedded in a conceptual understanding of teacher learning from PD activities as a complex dynamic system that embraces multiple mutually interacting and influencing components (Garner & Kaplan, 2021; Opfer & Pedder, 2011). Such learning systems, instead of being static, act and change over time in response to ever-changing conditions and restrictions. The interrelation and interdependency among the components of a learning system create non-linear teacher learning and unpredictable effects on how teachers learn and use their learning in practice (Opfer & Pedder, 2011). This view closely relates to the socio-cultural constructivism approach used to design and organize PD programs supporting teacher learning, highlighting the role of teachers' intra-personal values, characteristics, cognition, and agentic actions related to their inter-relations with others and interactions with environments (Russ et al., 2016). In a complex dynamic system for teacher learning from PD, teachers are viewed as agentic professionals with autonomous thinking and active choices rather than following a prescribed and programmed sequence (Opfer & Pedder, 2011). The notion of a complex dynamic system offers a lens underlining the role professional agency plays in the long-term effects of teacher learning resulting from PD activities. In the rest of the section, we review the literature on professional agency and clarify how we have defined and adopted this concept.

The concept of human agency has been widely explored and discussed. From a social-cognitive perspective, agency is defined as an individual's capacity to initiate intentional actions, Bandura (2006) emphasized an individual's motivation, belief, and self-efficacy to act and achieve, identifying four core properties of human agency: 1) intentionality (strategies); 2) forethought (goal setting and prospecting expected outcomes); 3) self-regulation (plans, actions, and implementation monitoring); and 4) self-evaluation and reflection. This perspective underlines individuals' self-efficacy, autonomy, and power to engage in agentic choices and actions (Priestley, Biesta, & Robinson., 2015).

From a post-structuralist perspective, agency is a temporally embedded social construct that responds to variables and changing orientations (Archer, 2000; Eteläpelto, Vähäsantanen, Hökkä, & Paloniemi, 2013). Scholars have also highlighted the collective nature of agency since agentic actions are associated with interactions in particular contexts, cultures, and structures (Archer, 2000; Priestley et al., 2015). Accordingly, agency involves individuals' capacity to collaboratively reflect social contexts and contribute to cultural and structural transformations over time (Hökkä, Vähäsantanen, & Mahlakaarto, 2017).

Further studies conceptualize agency as achieved by individuals through the interplay of personal capacities, resources, and social context constraints (Billett, 2006; Priestley et al., 2015). As Archer (2000) argued, individuals' power to exercise agency by using their knowledge, skills, and resources to make intentional choices and take action is always situated in particular social conditions and surroundings. Therefore, it is impossible to separate the individual from the social aspects of professional agency. Being socially distributed, agency demands individuals' mediation within their socially determined means (Vähäsantanen, 2015).

Highlighting the relationship between professional identity, agency, and work practices, Eteläpelto et al. conceptualized professional agency as "practiced when professional subjects and/or communities exert influence, make choices and take stances in ways that affect their work and/or their professional identities" (2013, p. 61). This proposed subject-centered socio-cultural approach offers a perspective to understand agency as subjective and individually developed through intentional efforts to affect change as well as an angle depicting how individuals exert deliberate professional influence through interactions and renegotiated professional identities amidst changing work conditions. Thus, professional agency is dynamically co-constitutive with individuals' socio-cultural environments. Agency manifestations should always be specified in local contextual conditions, including physical and material facilities and artifacts, power relations, institutional policies and cultures, and prevailing discourses and norms (Vähäsantanen, 2015; Wallen & Tormey, 2019). From this approach, agency is achieved rather than being static (Eteläpelto et al., 2013) and individuals are viewed not as passive carriers of their contextual conditions but as active agents influencing and transforming these conditions (Vähäsantanen et al., 2020).

2.2. Enacting professional agency in pedagogical change (impacting factors, sources, and constraints)

Agency manifestation and identity renegotiation are intrinsically temporal, involving continuity with the past through influential prior experiences and engagement with the present and the future through desired goals (Archer, 2000; Billett, 2006). In line with this, in a recent study, Du, Naji et al. (2021) proposed a conceptual framework for the development of university instructors' agency in the context of pedagogical change. The proposed framework includes three stages through which instructors may develop agency during a pedagogical change process: agency-for-action (activating prior experiences and preparing for change); agency-in-action (process of implementing change); and agency on prospects and future orientations.

Recent studies (Jääskelä, Poikkeus, Vasalampi, Valleala, & Rasku-Puttonen, 2017; Vähäsantanen, 2015; Vähäsantanen et al., 2020; Van Lankveld, Schoonenboom, Volman, Croiset, & Beishuizen, 2017) also identified both internal and external resources for agency manifestation and identity negotiation. The former include university instructors' prior experiences, personal goals, interests, values, self-efficacy of professional competences, and sense of professional identity regarding their pedagogical viewpoints on teaching and learning. The latter include personal relations with students and colleagues, the work culture and norms; the institutional environment, including facilities, policy, history, management, and leadership styles; and societal values of education. Both internal and external resources can either support or constrain university instructors' choices of and engagement with agentic actions and their renegotiation of professional identities.

Combining literature on agency development stages during PBL implementation with literature on agency sources for pedagogical change, the present study proposes a model of professional agency in PBL implementation to examine the long-term effects of a PD program on teacher learning (Fig. 1). The model provides an overview to understand teacher learning as part of the long-term effects of a PBL-based PD program. Including three stages of PBL implementation for university instructors, i.e., agency-for-action (readiness for change); agency-in-action (process of implementing change); and agency on prospects and future orientations, the model underlines the temporal nature of the dynamic complexity of teacher learning for changes in practice. Teachers' agentic choices are associated with the past (readiness for change), present (implementation of change in practice), and future (prospects for change) (Archer, 2000; Billett, 2006; Emirbayer & Mische, 1998). Each of the interrelated phases embraces diverse, interactive agency sources that reflect internal (intrapersonal) and external (relational, environmental, and situative) aspects.

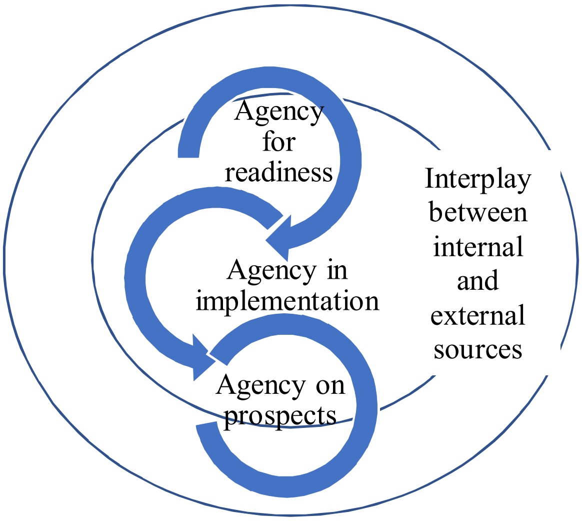


Fig. 1. Professional agency in PBL implementation to examine a PD program's long-term effects on teacher learning.

Supported by this model, the study explores which sources of professional agency are important in supporting teachers to implement PBL.

2.2.1. Agency for readiness stage

Within the phase of agency-for-action, the instructors' readiness for change is the major source of their agency to implement PBL (Du & Chaaban, 2020; Du, Naji, et al., 2021). Such readiness for change reflects individual teachers' intrapersonal characteristics and enactment of their own interests, values, and personal goals in the context (Bandura, 2006; Vähäsantanen et al., 2020). To enhance pedagogical innovation, teachers must be supported by their motivation, pedagogical beliefs, prior experiences, and self-efficacy regarding their skills and competences (Bandura, 2006; Billett, 2006; Priestley et al., 2015; Vähäsantanen, 2015). External sources such as socio-cultural and environmental aspects (e.g., institutional support through leader encouragement, policy requests) may be further important reasons for teachers to adopt practices towards new pedagogy.

Our previous studies (Du & Chaaban, 2020; Du, Kolmos et al., 2020; Du, Naji, et al., 2021; Du, Spliid et al., 2020) identified that teachers' pedagogical beliefs, e.g., whether PBL promotes student learning, serve as important drivers for their implementation of PBL. These drivers may derive from their values (e.g., caring for students), interests in learning more about pedagogy, literature studies, or belief in PBL implementation as a personal career development investment. Multiple external sources may also support teachers' engagement in PBL implementation, including prior experiences of learning from PD activities or inspiration from observing others. Finally, teachers may implement PBL due to institutional encouragement or request.

2.2.2. Agency in implementation stage

Self-organization is core to the agency in practice phase because teachers must adjust their preferences to the reality of their environment when implementing new practices (Garner & Kaplan, 2021; Russ et al., 2016). Internally, teachers are supported by their goals, plans, monitoring, reflection and self-reflection (Bandura, 2000), and emotions and resilience (Priestley et al., 2015; Wilcox & Lawson, 2018). These sources of agency may support university instructors' choice- and decision-making regarding the implementation of new pedagogical approaches, while missing agency sources may constrain their engagement to change. When exploring implementation, it is essential to examine environmental, cultural, and structural factors, instructors' relationships, such as student support and collaborative work with colleagues, and instructors' effective communication with their surroundings (Priestley et al., 2015; Vähäsantanen, 2015; Vähäsantanen et al., 2020; Wallen & Tormey, 2019).

Within the context of PBL implementation, instructors may activate prior experiences regarding PBL (e.g. as a learner in a PBL PD program). By planning the PBL process and following PBL principles to restructure course syllabi and assessment methods, they develop new teaching goals (Kolmos & De Graff, 2014). The implementation process should include significant interaction and interplay between teachers' internal and external sources of agency. Students' feedback and peer and institutional support (classroom facilities, schedule, materials, policy flexibility) are all important sources offering instructors opportunities to act unreservedly, maintain resilience, and adjust and reflect to continuously improve their practices. However, a lack of these external sources will demotivate instructors; they may choose passive ways to react or compromise the implementation. It was also suggested that when both instructors and students have minimal student-centered experience, in their first encounters with PBL, instructors tend to provide more direct input than is ideal in PBL to ensure students' achievements (Du, Naji, et al., 2021).

2.2.3. *Agency on prospects stage*

Within the agency on prospects and future orientations stage, professional agency is viewed as a developmental process that should support and impact teachers' life-long learning and career pathways (Vähäsantanen et al., 2020; Van Lankveld et al., 2017). Successful student learning resulting from pedagogical change should empower instructors with feelings of personal achievement, changed beliefs and values, and an appreciation of their efforts, which should also sustainably impact instructors' life-long learning regarding engagement with further pedagogical work (Wallen & Tormey, 2019). From a sustainability perspective, agentic individuals also influence others and create cultural and structural change over time (Priestley et al., 2015; Vähäsantanen, 2015; Vähäsantanen et al., 2020; Wallen & Tormey, 2019).

Understanding teacher learning from the PD program as a complex dynamic system (Garner & Kaplan, 2021; Opfer & Pedder, 2011), we consider that each participant develops their professional agency regarding actual practices of PBL in their situated environment. Garner and Kaplan (2021) further suggest that self-similarity may exist in teacher learning from PD insofar as collective or group awareness, beliefs, and dispositions are shared. In a process of educational change, Vähäsantanen (2015) notes that teacher collective agency also exists; this involves teachers' abilities to affect their environments collectively and collaboratively, thus eventually contributing to structural and cultural transformations. In a PBL implementation context, agentic instructors resource themselves through learning gains, efforts, and benefits from their experiences and empower themselves via further learning through additional PD activities or research work. Empowered by their changed values and beliefs, instructors develop initiative and leadership to further promote PBL by involving peers and influencing cultural change and policy enhancement at the institutional level (Du, Naji, et al., 2021). Therefore, the question of how instructors have shared experiences in the learning through practice stage during PBL implementation deserves attention.

In the following section, we connect the theoretical work on professional agency in PBL implementation to the empirical work of examining teacher learning through the long-term effects of a PBL-based PD program; we particularly describe how the model is linked with the research methodology through the developed Q concourse and statements.

3. Research Methodology

In the present study, we investigate the long-term effects of university instructors' participation in a PBL pedagogical program, focusing on their professional agency in implementing PBL. In particular, the study was guided by the research question *How do university instructors perceive aspects that impact their professional agency during the process of implementing pedagogical change such as PBL?*

3.1. *Participants*

Of the 70 university instructors who participated in the PBL PD program in Denmark, 56 (21 female and 35 male) working at diverse higher education institutions in China participated in this study (response rate 80%). Their mean age was 40.09 years; 41 of them had a Ph.D. at the time of data collection. Recruitment was conducted via the corresponding author's contacts from the PD program.

3.2. *Research design and procedure*

To address the central research question and access participants' subjective and often less-accessible perceptions, Q methodology (2019, Brown, 1980; Watts & Stenner, 2012) was selected as a fitting approach. As a methodology developed for small-scale research aiming to capture and contrast subjectivity, Q readily applies within diverse domains of higher education research, integrating both quantitative and qualitative characteristics (Woods, 2012). Built-in features of this approach allow researchers to access the most interesting and often underlying but nevertheless shared thought patterns within a participant group. This is achieved without imposing researchers' own categorizations, as is frequently the case in Likert-scale survey studies (Sung & Akhtar, 2017). Simultaneously, Q methodology helps to minimize the pitfalls of qualitative research, such as social desirability issues (Fluckinger, 2014).

In their systematic review, Lundberg, de Leeuw, and Aliani (2020) synergized a standard Q methodological procedure for educational research that included six steps: 1) concourse development, 2) Q set construction, 3) participant Q sorting, 4) post-sorting activities, 5) Q factor analysis, and 6) factor interpretation. This procedure was also used to guide Q in the current study.

Step 1 Concourse development

A *concourse* refers to a collection of statements about the topic; developing these statements demands significant knowledge in the field and intensive examination of literature studies and other sources that may represent the contextual nature of subjectivity (Brown, 2019). In the present study, the concourse was developed from the literature studies discussed in the theoretical sections of this paper, including previous research outcomes based on the experiences of the first cohort of the program) (Du, Kolmos et al., 2020). The first author, with over 18 years of experience researching PBL and supporting international PBL implementation and PD, proposed the initial concourse based on the literature studies, as discussed in section 2.

Step 2 Q set construction

In this stage, the model of professional agency in PBL implementation intended to examine the PD program's long-term effects on teacher learning, as described in section 2.2, is used as a tool to structure and select statements. The proposed model consists of three interrelated dimensions as a deductive starting point. As shown in Table 1, all statements in this study are assigned to a matrix in the model. Although the statements are categorized according to the three dimensions and three phrases, they are also understood to be interrelated and cross-dimensional.

While this theoretical step is useful for a deductive results-based discussion of the framework, Q methodology also allows the inductive emergence of new theories. Following the initial statements, the second author, an experienced Q researcher, facilitated an inductive and collaborative process with the first author, formulating the statements in an understandable and communicable way from the participants' self-referential point of view. To further facilitate participants' engagement with the items, the statements were presented in two languages: English and Chinese. Three program co-organizers were invited to review and comment on the statements. The process resulted in a 40-item Q set that was subsequently piloted by three participants to assess item formulation and translation and instrument validity regarding comprehensiveness. Based on the results of the pilot study, several minor adjustments were made, but no items were deleted or added.

Step 3 Participant Q sorting

Q sorting was administrated online during August 2020. An invitation was sent to all 70 participants via emails and WeChat, a common social media platform in China used by the participants as a group communication tool. This invitation introduced the research aims, format, and procedure, together with the consent forms. To collect data, we used QMethod Software (Lutfallah & Buchanan, 2019), which allowed us to gather demographic information about the participants in a pre-sorting survey, their sorting distribution through the actual sorting activity, and even additional qualitative insights into their decision-making through a post-sorting survey with open-ended questions.

A link was sent to 59 participants after they confirmed their participation in the study, and 56 responses were collected within the expected timeframe (response rate 80%).

By clicking the link, participants reached the Q sorting webpage. The online sorting process was conducted in a one-to-one mode, and participants were individually supported by the first author during the sorting activity via phone and WeChat software.

For the main activity, participants were instructed to rank-order 40 items, representing 40 aspects, according to their perceived importance in supporting participants' agency development in successfully implementing PBL. Using "drag and drop" in the online sorting tool, participants assigned each item a hierarchical position from "less important" (-5) to "rather important" (+5) in the forced-choice, quasi-normal and symmetrical distribution grid (see appendix 1 for an example of a completed grid). Through this highly engaging activity, each participant generated a single, holistic configuration of their viewpoints towards the question at hand. In the Q sorting process, participants were expected to constantly compare statements since Q items are treated in relative rather than absolute terms. Individuals applied their subjective views of their experience in implementing PBL, thereby rating which sources influenced their agentic choices more; this process resulted in a single holistic configuration generated through the described Q sorting technique.

Step 4 Post-sorting activity

Additional qualitative information about participants' ranking decisions was collected through a post-sorting survey with open-ended questions. Participants were asked to elaborate on the reasoning behind 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 implementation experiences. To investigate participants' overall perception of their agency in PBL implementation, two further questions were asked: "In which ways do you feel you have had autonomy in your PBL implementation process?" and "How do you perceive your ability to cope with the challenges in your professional life in general?"

Step 5 Q factor analysis

In order to perform Q sort correlations and inverted factor analysis, raw data from the QMethod Software was imported into KADE (Banasick, 2019). In this dedicated Q analysis tool, the most informative factor solution was found using Centroid Analysis and Varimax rotation. Seven factors, including a bipolar one that was later split into two separate factors (3a and 3b), were selected based on their qualitative value and theoretical significance. This rather unusual eight-factor solution is supported by the fact that all retained factors satisfy the most commonly used decision-making criteria (eigenvalues of 1.00 or above, two or more significantly loading participants per factor; Watts & Stenner, 2012). Moreover, factor intercorrelations were generally low, except between Factors 1 and 4 (0.4492), which can be considered two

Table 1
Q set construction

Implementation stages	Interrelated sources for professional agency for teacher learning	
	Internal (intrapersonal values and characteristics)	External (relational, situational, and environmental aspects)
Agency for change readiness stage	#2. I care for my students. #4. I like taking new challenges to learn. #9. Experimenting with PBL is potentially beneficial for my own personal and career development. #11. I read literature about PBL. #20. PBL is a good solution to providing students with the requested professional competencies. #28.PBL is appropriate for maximizing student learning in general. #30. Implementing PBL adds to my qualification to be academically promoted. #35. I want to become an educational expert.	#6. Initiating PBL implementation was encouraged by my institutional leaders. #8. PBL is appropriate for developing good engineering graduates in line with accreditation standards. #12. I was inspired by observing students' experiences with PBL from other courses. #18. I was requested by the institute on a policy level. #37. I attended professional learning activities. #40. I learned from other teachers' experiences with PBL.
Agency in implementingation	#7. I reflected upon the process of PBL implementation. #10. I made justifications for the modifications in my PBL implementation process. #13. I planned the PBL implementation. #15. I recalled my experiences as a learner in a PBL learning program. #21. I provided more direct instructions to support my students in their PBL process. #33. I revised intended learning outcomes to be aligned with PBL.	#1. I consulted a mentor when I encountered challenges in my PBL implementation process. #14. My PBL implementation plan was supported by my institutional leaders. #17. I was approved to redesign the assessment forms to be aligned with PBL. #19. I had someone to talk to during my PBL implementation. #22. Students in my PBL course have improved their learning outcomes compared to previous years. #23. I was approved to reschedule my class to make the time suitable for PBL implementation. #24. I was provided suitable physical facilities for PBL implementation. #25. I used student feedback at the end of the semester to improve my PBL implementation effort.
Agency on prospects	#5. I enjoyed my personal learning gains from the PBL implementation despite the efforts and time spent. #16. I engaged myself in further professional learning activities on pedagogical improvement. #26. I joined a research network on PBL. #32. Implementing PBL helped me rethink the values of education for society in general. #34. Implementing PBL helped me become an expert in pedagogy and educational research. #36. Through my PBL	#3. I discussed with leaders regarding how to further limit the constraints from an institutional perspective. #27. I shared my own experiences with PBL with colleagues. #29. I encouraged more colleagues to implement PBL. #31. I discussed with leaders regarding how to further expand the benefits of PBL from an institutional perspective. #38. My evaluation by my institute improved due to my efforts in PBL implementation.

(*continued on next page*)

Table 1 (*continued*)

Implementation stages	Interrelated sources for professional agency for teacher learning	
	Internal (intrapersonal values and characteristics)	External (relational, situational, and environmental aspects)
	experience, I realized that I was not the major source of authorized knowledge anymore. #39. I anticipated the development of my leadership to be able to make more pedagogical changes.	

different manifestations of the same factor (Watts & Stenner, 2012). Since the analysis showed interesting differences between these factors, they were treated and described separately despite not being mutually exclusive. Of the 56 participants, 37 loaded significantly on only one factor. Ten Q sorts were non-significant, while nine loaded significantly on two rotated factors. Because they made the factor arrays less distinct, these so-called confounded sorts were not considered for the respective factors.

Step 6 Q factor interpretation

Highly qualitative and holistic factor interpretation in Q aims to suggest plausible, well-informed explanations for effects observed across the range of factor arrays (a weighted average of values per item within one factor). These factor arrays formed the basis of the abductive and iterative interpretation process, which usually begins with a within-factor interpretation supported by participants' demographic information and post-sorting responses. To clarify factor differences, factor descriptions are enriched with an across-factor interpretation, whereby so-called distinguishing statements are the most relevant (see Table 2).

3.3. *Viewpoint validation and enrichment*

Based upon a recommendation in Hellström and Lundberg (2020), at least one highly significantly loading participant per factor was contacted to participate in a post-analysis interview four weeks after the Q sorting activity. The aim of this participatory approach is twofold. First, it can serve as a credibility check of preliminary factor descriptions (Duncan & Owens, 2011); second, it provides a deeper, more robust account (Brown & Militello, 2016) of how the participants perceived their experiences of choice-making, decision-making, and stance-taking within the PBL implementation. During the above-mentioned post-sorting survey, all participants had communicated their voluntary willingness to participate in this additional methodological step. The interviews, each lasting 20-30 minutes, were conducted in Chinese via WeChat and were recorded. They were later transcribed into Chinese text before being translated into English. Both languages were constantly compared during analysis to ensure that the condensed meanings embedded in the local context were exposed (Halai, 2007). During the interviews, which were structured based on the preliminary description of the viewpoint they significantly loaded on, participants confirmed the Q sorting analysis results and elaborated the reasoning behind their sorting decisions; they also narrated and further reflected upon their PBL implementation experiences. Table 3 presents an overview of the interview participants. The IDs stated in the table are used to reference participants in the qualitative description of their viewpoints.

4. Results

In the following sections, the factors that emerged during the Q analysis are described as *Viewpoints* to illustrate participants' own perceptions of the phenomena, thereby underlining the subjective character of the results. Each description stemmed from within and across factor interpretation and is structured to reflect the model of professional agency for PBL implementation, as discussed in section 2.2. The number of particularly characteristic statements is indicated in brackets, together with the assigned value in the specific factor array. Each statement is referred to as "# item number of the statement/values of the statement, e.g., 5 or -5." For example, "#11/4" refers to statement 11 with the value of 4. For statements that significantly differed between the viewpoints, we added a D after the value number, meaning "distinguishing statements" ($p < 0.05$), or D* for "significantly distinguishing statements" ($p < 0.01$). Table 4 provides an overview of the results for the described eight-factor solution.

Table 2
Distinguishing statements per viewpoint

	#	Statement	V1	V2	V3a	V3b	V4	V5	V6	V7
V1	35	I want to become an educational expert.	**5**	−2	0	1	0	−1	0	1
V2	9	Experimenting with PBL is potentially beneficial for my own personal and career development.	0	**-5***	0	2	−2	3	4	1
	16	I engaged in further professional learning activities on pedagogical improvement.	0	**4***	−4	1	−1	−5	−1	0
	19	I had someone to talk to during my PBL implementation.	−2	**3***	−1	−5	−3	−3	−4	−1
	28	PBL is appropriate for maximizing student learning in general.	4	**-3**	0	3	**5**	3	0	2
V3a	40	I learned from other teachers' experiences with PBL.	−2	−3	**4***	−1	−4	0	−2	−4
	7	I reflected upon the process of PBL implementation.	3	2	**-4***	3	4	5	4	4
	24	I was provided suitable physical facilities for PBL implementation.	−4	−2	**3**	−4	−2	0	−3	0
	5	I enjoyed my personal learning gains from the PBL implementation despite the efforts and time spent.	4	0	**-3**	2	3	0	**-5**	4
V3b	20	PBL is a good solution to providing students with the requested professional competencies.	2	4	4	**-4***	3	2	5	2
	3	I discussed with leaders regarding how to further limit the constraints from an institutional perspective.	−4	−4	−5	**4**	0	0	−4	0
	2	I care for my students.	1	5	3	**-2**	3	2	3	1
V4	28	PBL is appropriate for maximizing student learning in general.	4	**-3**	0	3	**5**	3	0	2
V5	12	I was inspired by observing students' experiences with PBL from other courses.	−1	2	−4	1	−1	**5***	−1	−5
	25	I used student feedback at the end of the semester to improve my PBL implementation effort.	0	2	1	4	2	**-3**	4	0
V6	30	Implementing PBL adds to my qualification to be academically promoted.	−5	−4	−1	−4	−5	−2	**5***	−1
	11	I read literature about PBL.	4	−1	1	0	0	1	**-5***	−1
	5	I enjoyed my personal learning gains from the PBL implementation despite the efforts and time spent.	4	0	**-3**	2	3	0	**-5**	4
V7	23	I was approved to reschedule my class to make the time suitable for PBL implementation.	−5	−1	−2	−1	0	−4	−4	**3***
	4	I like taking new challenges to learn.	2	0	0	0	1	2	0	**-5***
	21	I provided more direct instructions to support my students in their PBL process.	1	−1	−1	0	1	−1	−2	**3**
	36	Through my PBL experience, I realized that I was not the major source of authorized knowledge anymore.	0	0	2	−1	5	2	1	**-3**

Note: Statements that are significantly different between the viewpoints are indicated in bold ($p < 0.05$). An asterisk (*) indicates significance at $p < 0.01$.

Table 3
Participants selected for post-analysis interviews

V	ID	Specialization	Gender	Academic title	Age	Highest degree	PBL program
1	V1-6	Control science and engineering	male	Associate professor	39	Ph.D.	2018
	V1-13	Pharmaceutical engineering	female	Associate professor	47	Ph.D.	2017
2	V2-1	Energy and power engineering	male	Associate professor	37	Ph.D.	2018
3a	V3a-3	Veterinary technology	female	Associate professor	42	Ph.D.	2018
3b	V3b-2	Mathematics	male	Associate professor	49	Master	2017
4	V4-1	Geographic information science	male	Associate professor	45	Ph.D.	2017
5	V5-3	Statistics	female	Professor	43	Ph.D.	2017
6	V6-2	Computer science	male	Associate professor	39	Ph.D.	2018
7	V7-1	Statistical economics	male	Associate professor	40	Ph.D.	2017

Table 4
An overview of the results for the described eight-factor solution

Viewpoint	Sorts	% Expl. variance	Gender (m:f)	Academic title (a:b:c)	Age	Highest degree (Ph.D:Meg)	PBL program (2017:2018)	Highest ranked items (Stage:Source)	Lowest ranked items (Stage:Source)
1	16	17	10:6	3:5:8	40.625	13:3	9:7	#35: R-I #15: I-I	#30: R-I #23: I-E
2	2	5	2:0	0:1:1	34	2:0	1:1	#2: R-I #33: I-I	#9: R-I #34:P-I
3a	3	5	2:1	0:3:0	42.666	3:0	0:3	#37: R-E # 8: R-E	#3: P-E #31: P-E
3b	2	5	2:0	0:2:0	45.5	1:1	2:0	#33: I-I #31: P-E	#18: R-E #19: I-E
4	7	9	5:2	1:5:1	40.286	5:2	5:2	#28: R-I #36: P-I	#30: R-I #26: P-I
5	2	4	1:1	1:1:0	40.5	1:1	1:1	#12: R-E #7: I-I	#16: P-I #39: P-I
6	2	4	2:0	0:2:0	38.5	1:1	0:2	#30: R-I #20: R-I	#1: R-I #5: P-I
7	3	6	2:1	0:1:2	43.666	1:2	2:1	#32: P-I #17: I-E	#4: R-I #12: R-E
Total (sig. loadings)	37	55	26:11	5:20:12	40.757	27:10	20:17		
Confounded	9			0:6:3	40.333	6:3	4:5		
Non-sig.	10		8:2	1:7:2	37.4	7:3	4:6		

Academic titles: a: professor; b: associate professor; c: assistant professor
Stage: R: readiness stage; I: implementation stage; P: prospects stage.
Sources: I: internal sources; E: external sources.

4.1. Viewpoint 1 on becoming an educational expert / highlighting intrapersonal values for change

Internal sources were essential for the 16 participants associated with Viewpoint 1 to develop agency across the three stages of PBL implementation. For the readiness stage, they highlighted their desire to become educational experts (#35/5D), personal goals and interests in taking on new challenges to learn (#4/2), and efforts by reading literature (#11/4). For the implementation stage, they considered their internal source of personal learning experiences during the PBL PD program as highly important in supporting their PBL implementation practices (#15/5). For the prospects stage, they appreciated their learning gains from PBL implementation (#5/4) and the anticipated development of their leadership to successfully adopt additional pedagogical changes (#39/3).

Intrapersonal values and characteristics are further reflected in participants' post-survey responses, which confirmed their motivation and engagement in implementing PBL for pedagogical change. All participants reported positively about their confidence in tackling and navigating professional challenges; as one wrote, "I hope to take some changes. A good educator will benefit the educated for life, and a good education model will always give the educator a sense of achievement."

Further, both interview participants (V1-6; V1-13) expressed their gratitude for having learned about PBL by participating in the PBL development program, which provided them "an unforgettable experience of learning and personal transformation" and supported them with "pedagogical belief change to real student-centered learning" and "personal commitment to PBL implementation." One of them explained that

"Since I returned to my home university, I always recall my experiences as a learner in the PBL development program in Denmark. These experiences helped me to rethink how I shall change my own classroom. Based on these thoughts I have tried out PBL in different ways four rounds until now, which have greatly benefited my students and my own development. With these achievements, I am also more and more interested in doing more work on pedagogy in addition to my own field" (V1-13).

Simultaneously, these participants ranked academic promotion lower (#30/-5) for the readiness stage. Several external sources for the implementation stage, such as institutional approval for rescheduling class (#23/-5), redesigning the assessment (#17/-4), and having suitable physical facilities (#24/-4) were considered less important for their decisions and choices. They also deprioritized the importance of improved evaluations from their institutions (#38/-3) as external sources for the prospects stage. As one participant commented in his post-survey response, "Personally I believe that change of teaching methods demands rich experiences and the nature of the discipline, therefore I think it is more important I work on my own gaining experiences and development." He elaborated during the interview:

"The leaders would like to see achievements and success before they can engage to support for further bigger scale of change, therefore it is more useful I focus on my own classes with what I can do for now…" (V1-6).

In sum, for Viewpoint 1, intrapersonal aspects were more important to source agency across all three stages, while external factors, such as institutional aspects, were less important for their implementation and future perspectives.

4.2. Viewpoint 2 on further professional learning for larger change

Viewpoint 2 (two participants) also highlighted internal sources across the three stages, like Viewpoint 1, although they valued different statements. For the readiness stage, they emphasized the importance of their care for students (# 2/5) as a source for their agentic choices. For the implementation stage, they considered revising intended learning outcomes to align with PBL goals (#33/5) to be crucial. They also valued relational sources for the implementation stage, such as discussions with colleagues during PBL implementation (#19/3D*). For the prospects stage, they valued both the personal goal of engaging to improve pedagogically and further professional learning activities (#16/4D*) and the relational source of sharing experiences with colleagues (# 27/4).

Simultaneously, the statements they reported least important related to internal sources, including, for the readiness stage, whether their engagement with PBL would benefit their personal and career development (#9/-5D*) and, for the prospects stage, whether implementing PBL had helped them become pedagogical and educational research experts (#34/-5). They also reported as less important their belief in the appropriateness of PBL for maximizing student learning in general (#28/-3D) (readiness stage) and support received for their PBL implementation from institutional leaders (#14/-4) (implementation stage). Although both Viewpoints 1 and 2 highlighted internal sources, Viewpoint 2 placed less value on their personal development through PBL experiences, such as becoming an educational expert (#35/-2) (readiness stage) and recalling their learning experiences in the PBL development program (#15/-1) (implementation stage).

One interview participant confirmed these choices and further explained his thoughts:

"I became a department head after my study about PBL in Denmark, and I had to be a role model to practice it and show to my colleagues. Of course, I decided to implement PBL because I want my students to benefit from this….. it is more critical to get my colleagues accept this idea, in particular, they shall understand why I had to revise the course syllabus to fit PBL and make it correct… it was good that some close colleagues supported me on this so I could discuss with them along the way." (V2-1).

To support more of his colleagues in implementing PBL, his institute organized workshops in which he shared his experiences and updated colleagues. The participant also expressed his wish to engage in further professional learning activities on pedagogical improvement. He explained his low-ranked statements by saying that as a department head, he believed he should place department and program benefits ahead of his personal benefits.

Viewpoint 2 placed more value on the sustainable prospects of PBL implementation through their personal goals and plans to involve other colleagues in PD activities for pedagogical improvement. However, they did not prioritize personal benefits, including career development and promotion.

4.3. Viewpoint 3a External supports are important for readiness and implementation

The three participants of Viewpoint 3a highlighted the importance of external sources for both the readiness and implementation stages. For the former, they highly ranked their prior experiences of participating in PD activities (#37/5) and the appropriateness of PBL for engineering program accreditation standards (#8/5). They believed learning from other teachers' PBL experiences (#40/4D*) was highly useful for their own readiness. During implementation, suitable physical facilities were considered essential to support their PBL implementation (#24/3D). Further, these participants considered students' improved learning outcomes to be crucial (#22/4). One participant commented in the post-sorting survey that "Students (in China) are seriously lacking independent learning abilities, and PBL is suitable so it is important to support students to develop such skills through PBL".

For the prospects stage, these participants ranked institutional aspects lower. Discussing the expansion of PBL benefits with leaders (#31/-5) and reducing institutional constraints (#3/-5) were considered the least important. Other low-ranked aspects included relational and intrapersonal aspects, such as reflecting (#7/-4 D*) and consulting mentors (#1/-2) during implementation. The interview partner explained these responses:

"I believe they are important, and the reasons I placed them as less important are because firstly there is no mentor to consult, and then I am so busy with taking new tasks all the time, there is hardly time to calm down to reflect." (V3a-3).

Further, the interview partner explained her choices thus:

"As an individual university teacher, I think it is first important to hold a belief that what methods of teaching can best support students to develop their skills that are needed by their profession. PBL is suitable for all expected program outcomes in my field. Developing my own skills is the first important thing to do for me. Then I worked with students, convincing them that PBL is suitable to support them to develop their skills. It has been a cheerful experience over the three rounds of PBL implementation to observe students' development, starting from being silent in the PBL sessions to becoming highly active and engaged to self-directed activities. By choosing institutional factors as least important, I didn't mean they are not important. I think they are, but maybe at a later stage, when we have proved the effect from students and teachers, the institutional aspects would be more crucial" (V3a-3).

In sum, while Viewpoint 3a relied on external agency sources for their PBL readiness and implementation, future institutional development was not yet their priority.

4.4. Viewpoint 3b on the importance of institutional prospects

The two participants of Viewpoint 3b, contrasting with Viewpoint 3a, considered the institutional prospects of PBL, including discussing expansions of PBL benefits with leaders (#31/5) and reducing institutional constraints (#3/4D), highly important. They also highly ranked two statements at the implementation stage, highlighting the intrapersonal aspect of implementation through the importance of revising intended learning outcomes to align with PBL (#33/5) (in line with Viewpoint 2), and the relational aspect of implementation through using students' feedback to improve PBL efforts (#25/4).

Lower-ranked statements by Viewpoint 3b also represented external sources for agency readiness, such as a policy requesting PBL (#18/-5) or physical facilities (#24/-4), and agency implementation, such as having someone to talk to (#19/-5). This may relate to their interest in accepting challenges to improve professionally, as both participants mentioned in the post-survey. They did not highlight student-related aspects at the readiness stage; for example, they considered the belief that PBL may provide students with required professional competence (#20/- 4D*) and the appropriateness of PBL for accreditation standards (#8/-2) less important, differing considerably from Viewpoint 3a. Care for students (#2/-2D) and student improvement (#22/-3) were also not emphasized (#2/-2D), further differentiating Viewpoint 3b from Viewpoint 2. The post-survey responses offered explanations – participants already believed that PBL benefitted students because of the PBL PD program, and hence felt no need to further emphasize these beliefs. Rather, they focused on institutional aspects as more important to consider in practice.

During the interview, the participant shared his experience, which ranged from enthusiasm to disappointment due to lacking institutional support. As he said,

"I appreciated what I have learned in Denmark and was enthusiastic to implement PBL when I returned, following the principles I have learned….but to make further success, it is highly important that the leaders at my institute are interested in supporting this so the benefits can be larger." (V3b-2).

In sum, Viewpoint 3b expressed more concerns about their prospects for implementing PBL at the institutional level, suggesting that their individual PBL implementation practices would be essential but not sufficient.

4.5. Viewpoint 4 on pedagogical belief change – no longer the major source of authorized knowledge

Viewpoint 4 (three participants) highlighted intrapersonal sources across the three stages. For the readiness stage, they emphasized their beliefs on the appropriateness of PBL for maximizing student learning (#28/5D). For the implementation stage, like Viewpoint 2, they considered PBL implementation as a context-bound activity, and thus made modifications during the process (#10/4). For the prospects stage, they emphasized the change of their own role to no longer being the major source of authorized knowledge (#36/5). As the majority commented in post-survey responses, their pedagogical beliefs about their university teaching roles transformed through their learning experiences in the PBL program. They considered exploring alternative methods to maximize student learning more important than merely transmitting knowledge through lectures.

At the same time, Viewpoint 4 participants reported low values for intrapersonal sources across the three stages. For readiness, like Viewpoint 1, these participants did not value academic promotion (#30/-5). They also did not highly rank the importance of planning for PBL (#13/-3) during implementation or joining a research network (#26/-5) and rethinking the general values of education for society (#32/-4) in the prospects stage. Other low-ranked statements included relational sources during implementation, such as learning from other teachers' experiences (#40/-4). Explanations were provided in the post-sorting comments; as one wrote, "in my PBL implementation process, I put student learning as the first place, then myself as a teacher, then institutional and societal aspects." The interview participant from this viewpoint further explained,

"I think for this stage when I am still a beginner, it is more important to focus on how to support student learning and how to get the idea of PBL accepted by the institute. There is a long way before PBL can be accepted in many Chinese universities and in the society, so I put them as less important for now" (V4-1).

In sum, for Viewpoint 4, internal sources, such as changed pedagogical beliefs regarding the role of university teachers, mattered for PBL implementation. They focused on the appropriate implementation of PBL to benefit their students rather than prioritizing their personal benefit and development.

4.6. Viewpoint 5 on supporting PBL implementation by peer-observation and self-reflection

Viewpoint 5 (two participants) valued two relational sources: observed student experiences from other PBL courses (#12/5D*) (readiness stage), and improved evaluations from the institute (#38/4) (prospects stage). These participants also highlighted the role of reflection in PBL implementation (#7/5) during the implementation stage (unlike Viewpoint 3a). As elaborated in the interview:

"I decided to implement PBL when I observed how effective it was for the students in Denmark to work on real life problem project working with companies. This is what we should do in China to improve our students. Observing students and see the effectiveness of the PBL in the process is more important for me so I highlighted the role of reflection to ensure how it will go well. For me it is also important to get the acknowledgement from my institute" (V5-3).

Simultaneously, Viewpoint 5 considered internal sources for the prospect stage such as engaging oneself in further PD activities (#16/-5) and developing leadership for further change (#39/-5) as the least important. The interview confirmed that this was due to the focus on "making PBL implementation work for students so as to be conceded by the institute." Compared to other viewpoints, two relational aspects during implementation – students' improvement through PBL (#22/-3) and use of student feedback for improvement (#25/-3D) – were ranked lower. A post-sorting survey statement explains: "I had to teach new courses each semester so I spent lots of energy preparing for new contents and PBL at the same time. This made me feel unconfident in knowing how it works for students."

Another lower-ranked statement regarded an internal source for implementation, namely the revision of intended learning outcomes to align with PBL (#33/-4) (unlike Viewpoints 2 and 3). Elaborating on this, the interview partner mentioned that institutional policy prohibited changing the syllabus.

In sum, Viewpoint 5 valued peer-observation and self-reflection, as well as institutional recognition, to support their PBL implementation. Individual prospects, such as pedagogical development and leadership, were not prioritized, perhaps due to participants' heavy workloads constrained by other institutional expectations.

4.7. Viewpoint 6 on obtaining institutional recognition through academic promotion

The two participants of Viewpoint 6 emphasized internal sources, such as intrapersonal values at the readiness stage; in particular, they highly valued qualifying for academic promotion based on their PBL efforts (#30/5D*) (unlike Viewpoints 1 and 4) and perceived experimenting with PBL as potentially beneficial for their personal and career development (#9/4). They also highly ranked the belief that PBL would effectively provide students with requested professional competencies (#20/5) (significantly unlike Viewpoint 3b). According to the post-survey response and the interview (V6-2), this may be because despite participants' strong belief in PBL, being the only teachers implementing PBL in their environment makes it particularly important to gain institutional recognition through academic promotion, which also represents a way to "show real support for pedagogical change from the institute," as the interview partner expressed.

Also highly ranked was the use of student feedback to improve PBL efforts (#25/4) during implementation (unlike Viewpoint 5). Both participants related these choices to their positive PBL program experiences learning to improve their teaching through feedback.

Certain internal sources were ranked lower, including reading literature (#11/-5D*) for the readiness stage (significantly unlike Viewpoint 1) and individual prospects such as enjoying personal learning gains (#5/-5D) (unlike Viewpoints 1 and 7). They also did not value providing direct instructions to students (#21/-2); lack of direct instruction is an important PBL principle communicated in Denmark to support independent student learning, as explained in the interview.

In sum, Viewpoint 6 highlighted internal sources of readiness for PBL by valuing potential personal benefits, particularly opportunities to gain institutional recognition through academic promotion. Studying literature and appreciating learning gains from PBL implementation were the least prioritized aspects.

4.8. Viewpoint 7 on rethinking the values of education for society

Viewpoint 7 (three participants) highlighted the value of internal sources during the implementation and prospects stages and external sources during the implementation stage. From the prospects perspective, in stark contrast to Viewpoint 4, this viewpoint emphasized the importance of rethinking the values of education for society in general (#32/5). These participants also valued external sources during the implementation stage, including gaining approval for redesigning assessment forms to align with PBL (#17/5) and gaining approval to reschedule the class to a time suitable for PBL implementation (#23/3D*). The interview provided explanations:

"To implement PBL is not only a matter of changing my course, but more importantly it demands a dramatic change of the whole structure. The current course schedule needs to be changed so that students will have sufficient time to work on PBL. The assessment is where most change is needed. The whole educational system in China is focused on grades and exams. What students learn as competences is not really reflected from the current assessment methods. After all, it demands a change of societal ideology of what education is for" (V7-1).

In addition, they ranked internal sources highly, including PBL planning (#13/4) during the implementation stage and enjoyment of personal learning gains (#5/4) in the prospects stage. Post-sorting survey responses confirmed the importance of such aspects in effectively implementing PBL.

Nevertheless, compared to other viewpoints, Viewpoint 7 believed direct instructions to support students during the PBL process (#21/3D) were significantly more important (an internal agency source during implementation). This choice may connect to their post-survey response statements regarding institutional requests and limited autonomy. The interview partner elaborated that "course instructors are obligated to ensure important information to be delivered to students" (V7-1). This may also explain their belief that the changing role of teachers from being the major source of authorized knowledge was less important (#36/-3D) (an internal prospective source), differing significantly from Viewpoint 4.

Despite their claim of "welcoming challenges" in their post-survey responses, Viewpoint 7 respondents reported "taking challenges to learn" (#4/-5D*) – an internal source of readiness – as the least important aspect. The interview discussion explained this choice:

"Choosing this item (of taking challenges) as -5 does not mean I don't think it is important, but rather, in an environment lacking support and encouragement, I feel there is limited space to take challenges. In addition, I am pretty much alone in implementing PBL, there are no one to discuss and no one to consult." (V7-1)

Other external sources of readiness were considered less important, including obtaining inspiration by observing students' experiences from other PBL courses (#12/-5) (unlike Viewpoint 5) and receiving encouragement from institutes (#6/-3). Other relational factors were also ranked lower, including consulting a mentor (#1/-2) during implementation, sharing experiences with colleagues (#27/-3), and encouraging more colleagues to implement PBL (#29/-4) during the prospects stage.

In sum, internal prospective sources, including anticipating the long-term effects of societal value changes through PBL implementation, were highly valued by Viewpoint 7. Nevertheless, this viewpoint was also contradictory; while participants emphasized sources for implementation and prospects, they also ranked sources for readiness lower, indicating a dilemma between their anticipation of PBL practice and sustainable development and their lack of readiness due to contextual constraints.

4.9. Areas of consensus and shared concerns

Although Q methodological analysis found no statement with statistically significant consensus among the viewpoints, they agreed on the importance of several aspects, such as making modifications (#10) or recalling one's own experiences as a learner in the PBL program when implementing PBL (#15). This was also confirmed by the qualitative data from the post-sorting survey responses and the post-analysis interview results. Furthermore, the participants largely shared uncertainty about consulting a mentor in the case of challenges (#1), mainly because no mentors were available. As explained in the interviews, the participants in our study identified as pioneers in their higher education institutions. The Q-sort analysis also revealed an agreement on the reported low importance of institutional support. However, the verification in the post-survey and interview data disclosed a serious lack of support during participants' PBL implementation processes.

Further thematic analysis of the post-survey responses (53 of the 56 participants responded to all questions) and interviews identified three shared concerns and challenges in the process of PBL implementation.

First, despite their admiration for the PBL model in Denmark, most (around 90%) of the respondents saw few opportunities to transfer this ideal model to their local context. Thus, each participant individually developed adaptations of the PBL that suited their own locally bounded courses.

Second, a lack of institutional support and engagement was shared by participants across all viewpoints, regardless of whether they considered institutional aspects to be the most or the least important. Despite the overall policy of encouraging pedagogical innovation in Chinese universities, actual practical support remains ambiguous and participants felt limited autonomy to change teaching practices within the rigid system.

Third, around two-thirds of the post-survey respondents and all interview participants mentioned concerns about whether students would accept and cooperate with the PBL implementation. The participants also revealed different strategies to navigate student resistance. Such plans of action ranged from supporting students in recognizing the value of PBL to adapting PBL to please students.

5. Discussion

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

5.1. Discussion of the results related to the theoretical model

The present study aimed to explore how Chinese university instructors enacted their professional agency in PBL implementation after participating in a PBL development program in Denmark as long-term outcomes of their participation in a PD program on teacher learning. The Q study allowed eight viewpoints to emerge reflecting the instructors' perceptions of agency sources for PBL implementation, explaining 55% of the total variance within the sample. The participants described their engagement in pedagogical change through implementing PBL in their actual practices, providing positive results regarding the long-term effects of PD activities. While implementing PBL, these instructors navigated choices, decisions, and actions to develop new pedagogical practices, influence their work through interactions with colleagues and the institutional environment, and renegotiate their professional identity (Vähäsantanen, 2015; Vähäsantanen et al., 2020; Van Schalkwyk et al., 2015). Such results provide insights into the evaluation of PD activities' long-term effects (Assen et al., 2016; Bond & Blevins, 2019; Chalmers & Gardiner, 2015; Saroyan & Trigwell, 2015), particularly in the area of training teachers to implement PBL (Pecore, 2013). The characteristics of the PD program examined in this study, including its time duration (six months), scope (full-time participation), and format (organized in a PBL based methodology) may contribute to positive long-term effects seen through changes in actual pedagogical practice (Russ et al., 2016). Nevertheless, the current study focuses on the participants' professional agency during implementation stage via a self-reported mode, there may be multiple ways of examining long-term effects of PD programs.

Conceptualizing teacher learning in a complex dynamic system, the results also revealed significant diversity in participants' subjective experiences of how they enacted agency through their decisions to implement PBL, strategy choices during the process, and resilience to continue despite encountered challenges (Bickerstaff & Cormier, 2015; Campbell & O'Meara, 2014). They thereby demonstrated that agency, as a core of learning, is what people do and practice instead of what people have (Vähäsantanen et al., 2020). Through these enactments, the participants in our study renegotiated their professional identities through professional commitments, interests, goals, values, and prospects for

Table 5
Emphasized agency sources by viewpoints

Stages	Internal sources	External sources
Agency for readiness	Viewpoints 1, 2, 4, 6,	Viewpoints 3a, 5
Agency in implementation	Viewpoints 1, 2, 3b, 5, 7	Viewpoints 2, 3a, 3b, 5, 6, 7,
Agency on prospects	Viewpoints 1, 2, 4, 7	Viewpoints 2, 3b, 5

both individual careers and institutional perspectives (Van Lankveld et al., 2017). This further supports the view that the long-term effects of teachers' learning from PD activities, reflected through their teaching practices and engagement to support student learning, are highly situative and context-bounded (Garner & Kaplan, 2021; Opfer & Pedder, 2011; Russ et al., 2016).

To examine the long-term effects of the PBL pedagogical program on teacher learning, section 2.2. proposed a model of professional agency for PBL implementation based on a literature review. Accentuating the temporal nature of professional agency (Archer, 2000; Billett, 2006), the model's three proposed phases were demonstrated in the current study: past – participants' self-preparations to be ready for PBL implementation; present – agentic actions during the implementation; and future – further improvement and expansion of PBL. The results of the present study also illustrate teachers' varying views of the sources of professional agency they rely on, both internal (intrapersonal values and characteristics) and external (relational, situational and environmental aspects) (Jääskelä et al., 2017; Priestley et al., 2015; Van Lankveld et al., 2017; Vähäsantanen, 2015; Vähäsantanen et al., 2020), throughout the three phases. In general, these eight viewpoints provide new perspectives, highlighting the range of university instructors' perceptions and subjectivity. Table 5 arranges the predominantly emphasized agency sources by individual viewpoints.

Six out of the eight viewpoints highlighted readiness for change as an important source of agency in implementing PBL. While internal sources were underlined by Viewpoints 1, 2, 4, and 6, valuing different intrapersonal characteristics such as motivation, interest, beliefs, and efforts to individually prepare for PBL implementation, Viewpoints 3a and 5 underscored external sources, highlighting relational and institutional aspects as drivers for PBL practice.

The seven viewpoints emphasized agency sources for implementation, suggesting that this stage demands the most agentic choices and actions (Du, Naji, et al., 2021). Among them, Viewpoints 2, 3b, 5, and 7 highlighted both internal and external sources, indicating that in the practice of implementing new pedagogy, internal and external sources are highly interrelated and interactive, with teachers constantly making choices in negotiation with their surroundings (Garner & Kaplan, 2021; Opfer & Pedder, 2011; Russ et al., 2016; Vähäsantanen, 2015; Vähäsantanen et al., 2020). Surrounding factors such as student feedback, peer colleague acceptance, and institutional policy create constant emergence, requiring teachers to develop self-organization strategies to react to and act on situations (Archer, 2000; Bandura, 2006; Billett, 2006). At this stage, teachers may enact proactively if they have access to internal and external sources; however, lack of sources may lead to a passive reaction characterized by disappointment, confusion, and frustration (Wilcox & Lawson, 2018; Wood, 2012).

Six viewpoints highlighted the prospects stage of PBL. Viewpoints 1, 2, 4, and 7 underlined internal agency sources such as appreciating learning gains and individual benefits, reflecting on belief changes and personal development, and engaging in further PD activities and educational research. Viewpoints 2 and 3b underscored external agency sources, including involving more colleagues in joint efforts towards PBL and engaging in institutional change. Valuing agency at this stage generates more institutional sustainability for further educational change (Vähäsantanen, 2015; Vähäsantanen et al., 2020).

5.2. Practical implications for PD activities

The results of the study illustrate how instructors perceive their agency when implementing new pedagogies such as PBL. For PD activity developers and organizers, the results suggest that a process-product approach highlighting standardized participant learning outcomes will not be effective due to the complex reality of teachers implementing new pedagogical practices. Therefore, there is no "one-size-fits-all" solution; rather, teacher learning must be viewed as a complex dynamic system in which each teacher relies on multiple intrapersonal, relational, and environmental sources of agency for their actual practices.

The results of this study indicate that professional agency appears in local contexts in reaction to situated conditions, including facilities, materials, policy, norms, and power relations (Vähäsantanen, 2015; Wallen & Tormey, 2019; Wilcox & Lawson, 2018) as well as teachers' intrapersonal values, motivation, efficacy, and goals (Bandura, 2006). For pedagogical change to be sustainable, individual teachers must develop self-awareness of diverse agency sources to empower themselves. Even more importantly, institutional leaders must facilitate opportunities for instructors to be empowered individually and collectively with support from multiple sources for their agentic actions (Vähäsantanen, 2015). To build this capacity individually, collectively and institutionally, structural and cultural transformations over time (Hökkä et al., 2017; Wallen & Tormey, 2019; Wilcox & Lawson, 2018) are required.

5.3. Methodological reflection

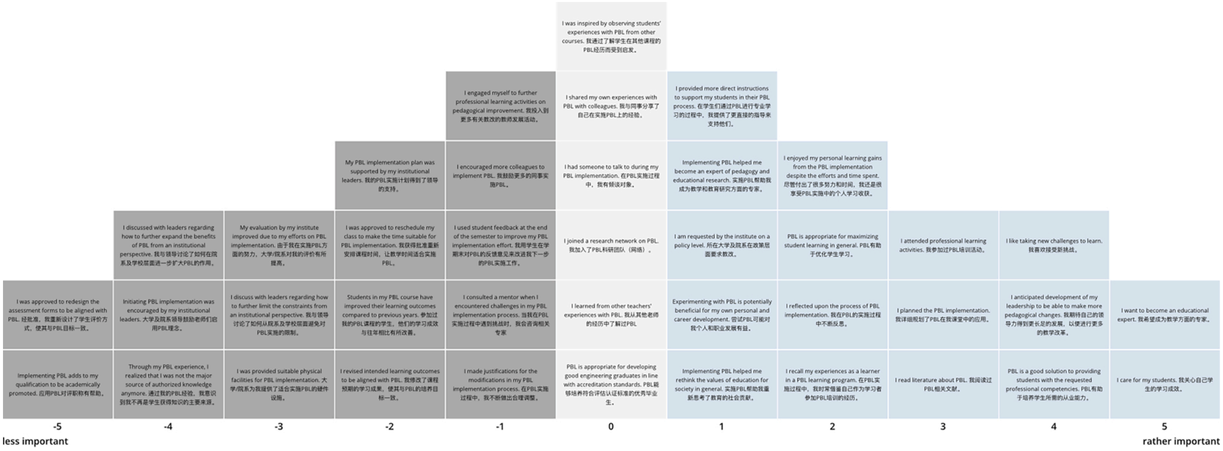
Earlier studies have reported how professional agency was enacted in a context of educational change through teachers' narrative inquiries (Vähäsantanen, 2015) and how university instructors developed professional agency through PBL implementation using a longitudinal ethnographic approach (Du, Naji, et al., 2021). However, these studies used a very small sample size (less than 10). The Q methodology allows us to involve a larger group of participants (n = 56) and a higher sampling rate (80%). Rather than judging the participants' performance, the results illuminate different subjective opinions and situative interactions between the individuals and their surroundings. The selected approach also provided space to investigate the similarities and differences among various viewpoints. Through a post-sorting survey and post-analysis interviews, participants were able to verify and further elaborate on their choices of the most and least important statements, explaining their thoughts, intentions, and reasons for those choices. This also underscores Q's potential for critical reflection and mediation (Lundberg et al., 2020) and confirms its suitability for structuring interviews to obtain credible Q results and provide further in-depth information (Duncan & Owens, 2011; Brown & Militello, 2016).

5.4. Limitations of the study and future perspectives

The study is limited in several ways. First, while the response rate was high (80% of the targeted population) and the number of participants (n = 56) was above the mean for recent Q methodological studies in educational research (Lundberg et al., 2020), the viewpoints of the remaining PBL program participants may have offered additional interesting variations. Second, although post-survey responses and interviewees confirmed many of the relevant aspects in the final Q set, additional statements reflecting on further aspects of professional agency in PBL implementation may exist. Third, using an online software tool may have challenged the communicative character of Q sorting. However, by providing one-to-one online support for participants responding to the Q-sort, we not only eliminated any technological barriers but also captured qualitative insights into participants' reasoning during the actual data collection activity. Finally, we acknowledge the potential difficulties of the detailed and wide range of viewpoints in this study. Fewer items to sort by participants might have yielded fewer viewpoints and thereby made the results clearer. However, the diverse outcome presented here can be seen as a manifestation of the investigated issue's complexity.

The results of the present study also suggested directions for future research. First, it would be worth investigating university instructors' viewpoints on pedagogical change in other contexts, including their enactment of professional agency in practice after attending training programs with shorter-term or different formats, which is rarely addressed in the extant literature (Assen et al., 2016; Saroyan & Trigwell, 2015). Second, the results of the current study may be combined with the outcomes of other research methods on the long-term effects of PD activities, such as a thematic analysis of in-depth interviews and case studies. Third, while the current study explored how university instructors perceived their own agency while implementing PBL, future research can also explore other perspectives, such as the perspectives of institutional leaders, managers, and administrators on instructor agency for pedagogical change, as these are considered important agents for promoting efficient educational change (Bickerstaff & Cormier, 2015; Campbell & O'Meara, 2014; Chalmers & Gardiner, 2015).

Appendix 1



					I was inspired by observing students' experiences with PBL from other courses. 我通过了解学生在其他课程的PBL经历而受到启发。					
				I engaged myself to further professional learning activities on pedagogical improvement. 我投入到更多有关教改的教师发展活动。	I shared my own experiences with PBL with colleagues. 我与同事分享了自己在实施PBL上的经验。	I provided more direct instructions to support my students in their PBL process. 在学生们通过PBL进行专业学习的过程中，我提供了更直接的指导来支持他们。				
			My PBL implementation plan was supported by my institutional leaders. 我的PBL实施计划得到了领导的支持。	I encouraged more colleagues to implement PBL. 我鼓励更多的同事实施PBL。	I had someone to talk to during my PBL implementation. 在PBL实施过程中，我有倾谈对象。	Implementing PBL helped me become an expert of pedagogy and educational research. 实施PBL帮助我成为教学和教育研究方面的专家。	I enjoyed my personal learning gains from the PBL implementation despite the efforts and time spent. 尽管付出了很多努力和时间，我还是很享受PBL实施中的个人学习收获。			
	I discussed with leaders regarding how to further expand the benefits of PBL from an institutional perspective. 我与领导讨论了如何在院系及学校层面进一步扩大PBL的作用。	My evaluation by my institute improved due to my efforts on PBL implementation. 由于我在实施PBL方面的努力，大学/院系对我的评价有所提高。	I was approved to reschedule my class to make the time suitable for PBL implementation. 我获得批准重新安排课程时间，让教学时间适合实施PBL。	I used student feedback at the end of the semester to improve my PBL implementation effort. 我用学生在学期末对PBL的反馈意见来改进我下一步的PBL实施工作。	I joined a research network on PBL. 我加入了PBL科研团队（网络）。	I am requested by the institute on a policy level. 所在大学及院系在政策层面要求教改。	PBL is appropriate for maximizing student learning in general. PBL有助于优化学生学习。	I attended professional learning activities. 我参加过PBL培训活动。	I like taking new challenges to learn. 我喜欢接受新挑战。	
I was approved to redesign the assessment forms to be aligned with PBL. 经批准，我重新设计了学生评价方式，使其与PBL目标一致。	Initiating PBL implementation was encouraged by my institutional leaders. 大学及院系领导鼓励老师们启用PBL理念。	I discuss with leaders regarding how to further limit the constraints from an institutional perspective. 我与领导讨论了如何从院系及学校层面避免对PBL实施的限制。	Students in my PBL course have improved their learning outcomes compared to previous years. 参加过我的PBL课程的学生，他们的学习成效与往年相比有所改善。	I consulted a mentor when I encountered challenges in my PBL implementation process. 当我在PBL实施过程中遇到挑战时，我会咨询相关专家	I learned from other teachers' experiences with PBL. 我从其他老师的经历中了解过PBL	Experimenting with PBL is potentially beneficial for my own personal and career development. 尝试PBL可能对我个人和职业发展有益。	I reflected upon the process of PBL implementation. 我在PBL的实施过程中不断反思。	I planned the PBL implementation. 我详细规划了PBL在我课堂中的应用。	I anticipated development of my leadership to be able to make more pedagogical changes. 我期待自己的领导力得到更长足的发展，以便进行更多的教学改革。	I want to become an educational expert. 我希望成为教学方面的专家。
Implementing PBL adds to my qualification to be academically promoted. 应用PBL对评职称有帮助。	Through my PBL experience, I realized that I was not the major source of authorized knowledge anymore. 通过我的PBL经验，我意识到我不再是学生获得知识的主要来源。	I was provided suitable physical facilities for PBL implementation. 大学/院系为我提供了适合实施PBL的硬件设施。	I revised intended learning outcomes to be aligned with PBL. 我修改了课程预期的学习成果，使其与PBL的培养目标一致。	I made justifications for the modifications in my PBL implementation process. 在PBL实施过程中，我不断做出合理调整。	PBL is appropriate for developing good engineering graduates in line with accreditation standards. PBL能够培养符合评估认证标准的优秀毕业生。	Implementing PBL helped me rethink the values of education for society in general. 实施PBL帮助我重新思考了教育的社会贡献。	I recall my experiences as a learner in a PBL learning program. 在PBL实施过程中，我时常借鉴自己作为学习者参加PBL培训的经历。	I read literature about PBL. 我阅读过PBL相关文献。	PBL is a good solution to providing students with the requested professional competencies. PBL有助于培养学生所需的从业能力。	I care for my students. 我关心自己学生的学习成效。
-5	-4	-3	-2	-1	0	1	2	3	4	5
less important										rather important

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