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Barriers and Facilitators of Teachers' Teaching Competency Development in Project-Based Learning: Insights from Chinese Primary School Teachers' Experiences

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Abstract

PBL design and implementation remain challenging, despite its prominence in 21st-century curriculum reforms. Teachers often reduce it to superficial thematic activities or product showcases, rather than facilitating students' authentic inquiry and meaningful learning. To better support in-service teachers in integrating PBL into disciplinary instruction, this study examines the experiences of 25 primary school teachers in Shenzhen, China, who participated in a 12-month professional development program. Utilizing in-depth interviews and focus groups, the study indicates a journey from initial concerns to gradual recognition of PBL and identifies three key teaching competency barriers: limited cognitive understanding of PBL, difficulties adapting to PBL implementation, and negative perceptions of PBL outcomes. Crucially, the findings reveal enabling factors that counterbalance these challenges, which are sustained expert scaffolding and practice-oriented teacher collaboration. These findings contribute to understanding the trajectory of professional growth in PBL and offer evidence-based strategies for optimizing the design of practice-oriented teacher development programs, particularly in contexts balancing examination pressures with pedagogical innovation.

Keywords: project-based learning; primary school teachers; professional development; teaching competency

1. Introduction

Project-Based Learning (PBL) has become a key approach in many countries' competency-based curriculum reforms due to its distinctive value in cultivating 21st-century skills, including critical thinking, collaboration, and problem-solving. Despite the growing policy emphasis on PBL, a persistent gap remains between curriculum intentions and classroom practices. When schools attempt to translate theoretical advocacy into practical implementation, teachers often encounter deep-rooted tensions between established instructional traditions and the demands of PBL. These tensions include structural mismatches between disciplinary-based epistemologies and interdisciplinary integration, conflicts between didactic teaching routines and inquiry-driven student learning, and institutional accountability systems that prioritize short-term, measurable outcomes over process-oriented learning (Guerra et al., 2022; Bairy & Inamdar, 2024).

This "high expectation, low effectiveness" scenario reflects the underlying dilemmas in PBL implementation. In China, PBL implementation is constrained by an exam-driven

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system, rigid disciplinary boundaries, and a teacher-centered tradition (Meng et al., 2023; Arango-Caro et al., 2025). Unlike teachers in Finland or the US, who enjoy curriculum autonomy (Owens & Hite, 2022), Chinese teachers operate under high-stakes testing, making PBL a negotiation with institutional expectations.

However, current research on teachers' PBL teaching competency suffers from two main limitations. On the one hand, most studies are based on educational contexts where teachers have autonomy in curriculum design and institutional support for interdisciplinary collaboration (He et al., 2023). which overlook the structural constraints characteristic of school settings in China, such as rigid subject boundaries and a standardized exam-driven system. On the other hand, existing research often evaluates teacher's PBL teaching competency through checklist-based indicators (e.g., "designing driving questions" or "managing student collaboration") (Talbot et al., 2022; Ma & Wu, 2025), failing to capture the dynamic and agentic processes through which teachers adjust their cognitive understanding, emotional attitudes, and instructional strategies in complex classroom settings. These research gaps urgently call for contextually grounded empirical exploration.

Therefore, within the disciplinary-centric and exam-driven institutional and cultural constraints of Chinese primary schools, this study adopts a qualitative research approach to examine Chinese primary school teachers' experiences in designing and implementing PBL, aiming to uncover the key mechanisms influencing the development of their PBL teaching competencies. The study seeks to answer the following questions:

(1) How do teachers' experiences evolve in the design and implementation of PBL?
(2) What barriers do teachers encounter during the design and implementation of PBL, and how do these barriers emerge and interact with one another?
(3) What are the key factors that help teachers overcome the barriers to PBL and facilitate their instructional practice and PBL teaching competency development?

Based on the research questions above, the specific objectives of this study are to characterize the developmental trajectories of Chinese primary school teachers experiences in designing and implementing PBL, to identify and map the barriers teachers encounter during PBL implementation as well as the mechanisms by which these barriers emerge and interact, and to determine the key enabling factors that support teachers in overcoming barriers and facilitating their instructional practice and PBL teaching competency development.

2. Literature Review and Theoretical Framework

2.1. Teachers' PBL Teaching Competency

Compared with traditional knowledge-centered instruction, the design and implementation of PBL requires teachers not only to master pedagogical knowledge and skills grounded in authentic contexts but also to reconstruct their professional identity and teaching practices. Extensive research has demonstrated that effective PBL necessitates a set of integrated and multifaceted competencies, including: (1) the ability to design authentic, complex contexts and driving questions or tasks; (2) interdisciplinary knowledge integration; (3) instructional skills for guiding student inquiry; (4) the ability to scaffold and manage project progression; and (5) capacity for assessing both learning processes and outcomes (Bolick et al., 2024; Ma & Wu, 2025).

Specifically, teachers must transform curriculum standards into authentic driving questions (Krajcik & Czerniak, 2018; He et al., 2023), shift from knowledge transmission to facilitation and collaborative support, and develop competencies in learning facilitation, technology integration, and pedagogical reflection (Tsybulsky & Muchnik-Rozanov, 2023; Gómez-Pablos et al., 2017).

Evidently, PBL is profoundly reshaping the professional competency requirements for teachers. However, for teachers, PBL is not merely a process of cognitive and strategic development—it is also an educational practice with a significant emotional dimension (Pan et al., 2024). Nonetheless, there is limited research focusing on teachers' emotional responses or attitudes toward PBL.

2.2. PBL and Teachers' Professional Development

Existing research indicates that many in-service teachers lack the essential knowledge and skills to successfully integrate PBL into their routine disciplinary instruction (Frank, 2025; Guaya et al., 2025). For example, the implementation of PBL in practice is often incomplete and unsystematic, frequently manifesting as "dessert projects" or short-term, school-based initiatives that struggle to achieve sustained depth and continuity (Guaya et al., 2025). Cai et al. (2023) found that while Chinese teachers generally hold positive attitudes toward PBL, their attitudes are significantly influenced by training, social support, resources, and time availability. Farrow et al. (2024) further confirmed that teachers' PBL design features often fail to translate into high-quality classroom enactment. Other research has similarly documented that without adequate professional development, teachers tend to enact PBL in procedural or fragmented ways (Farrow et al., 2022; Molina-Torres, 2022).

Beyond these general challenges, teachers often face additional professional obstacles that complicate access to continuing professional development (CPD). Heavy administrative burdens often leave limited time for collaborative planning and professional development (Zeng et al., 2025). Studies on STEM education (Lyu et al., 2022) and initial teacher training (Molina-Torres, 2022) highlight that teachers struggle with interdisciplinary inquiry and have methodological deficiencies in active learning, as traditional teacher training has often emphasized content knowledge over student-centered pedagogies (Cai et al., 2023). Developing PBL teaching competency requires more than discrete techniques. Sustained, practice-embedded professional development enables teachers to enact PBL in rich, authentic ways (Farrow et al., 2022), and collaborative lesson study can deepen teachers' understanding and enactment (Qi et al., 2023). Yet such "deliberate, ongoing and gradualistic" opportunities remain scarce in many educational contexts (Trepper et al., 2022).

Therefore, to effectively embed PBL into disciplinary instruction, teachers typically require CPD support—such as content learning, collaboration, expert guidance, and reflection (Darling-Hammond et al., 2017). Nevertheless, most current professional development initiatives remain centered on one-off expert lectures or workshops, lacking both continuity and classroom-embedded relevance. Such fragmented formats are insufficient to catalyze deep instructional change among teachers and have a limited impact on improving student learning outcomes. Effective CPD requires immersive, job-embedded approaches that connect teacher learning to daily classroom challenges through collaboration and expert coaching (Voet & De Wever, 2019), aligning with experiential learning theory (Kolb, 1984) and professional learning communities (Wiliam & Leahy, 2018).

2.3. Chinese Primary School Teachers' Professional Development

Chinese primary school teachers operate within a distinctive structural and cultural context that shapes their professional development. The centralized, exam-driven system with rigid disciplinary boundaries and fixed instructional periods transforms PBL implementation from a technical adjustment into a negotiation with institutional expectations (Meng et al., 2023; Arango-Caro et al., 2025).

Chinese primary school teachers face significant challenges in their professional development. Regarding attitudes and influencing factors, Cai et al. (2023) found that while Chinese teachers generally hold positive attitudes toward PBL, their attitudes are significantly influenced by training, social support, resources, and time availability, suggesting that positive attitudes alone are insufficient for effective implementation. Regarding inquiry-based working, Luo et al. (2025) conducted a large-scale study of 5566 primary teachers across seven Chinese cities and found that teachers feel challenged to engage in inquiry-based working when tackling school-level problems, with large disparities between rural and urban schools. Regarding interdisciplinary teaching skills, Tian et al. (2025) found that professional development had a significant positive effect on teachers' interdisciplinary teaching skills, with epistemological and pedagogical beliefs playing mediating roles. Additionally, Zeng et al. (2025) found that Chinese teachers are often required to undertake heavy administrative tasks alongside teaching duties, leaving limited time for collaborative planning and professional development. Traditional teacher training in China has emphasized content knowledge over student-centered pedagogies (Cai et al., 2023), and preservice teachers often have methodological deficiencies in active learning (Molina-Torres, 2022), perpetuating a cycle of teacher-centered instruction.

Compared with Japan and Singapore, China faces greater challenges in PBL adoption. Japan has a well-established lesson study (jugyokenkyu) tradition, which provides a systematic, collaborative framework for teacher professional development that supports the gradual implementation of innovative pedagogies (Suzuki, 2022). Singapore has systematically integrated PBL into its national curriculum through the "Teach Less, Learn More" initiative, with dedicated professional development structures and resources to support teachers (Ho & Lee, 2022). In contrast, China's more rigid disciplinary boundaries, high-stakes testing environment, and teacher-centered tradition pose greater challenges for PBL adoption. These comparisons suggest that China could benefit from adopting elements of Japan's lesson study approach and Singapore's systemic professional development infrastructure to better support teachers in developing PBL teaching competencies.

2.4. Theoretical Framework

To gain an in-depth understanding of teachers' experiences in PBL design and implementation, as well as the influencing factors on their instructional competency during professional development, we relied on the Interconnected Model of Professional Growth (IMPG) proposed by Clarke and Hollingsworth (2002) to analyze the interactions among various domains in teachers' PBL teaching competency development. The IMPG emphasizes the interactive and dynamic nature of teacher learning, proposing that growth occurs through reflective practice across four interconnected domains: (1) the external domain, encompassing all external resources available to teachers (e.g., workshop, books, and literature, and expert input); (2) the practice domain, where teachers enact ideas and observe outcomes; (3) the personal domain, involving ongoing changes in teachers' knowledge, beliefs, and attitudes; and (4) the domain of consequence, involving evaluating the effectiveness of the approach and deciding what adjustments are required. Central to the model are the mediating mechanisms of reflection (making sense of experiences) and enactment (translating ideas into action), which connect these four domains and enable professional growth to occur through multiple pathways rather than a fixed sequence (Clarke & Hollingsworth, 2002).

Previous research using the IMPG model has demonstrated its utility across various educational contexts. Vreekamp et al. (2023) conducted a systematic review of 31 peer-reviewed articles using the IMPG to explore relationships between pedagogical

development programme characteristics and teacher development outcomes, yielding an enriched model for understanding higher education teacher development. Vlcek and Sedova (2025) applied the IMPG to examine how six novice teachers in the Czech Republic perceived the development of their professional competencies over two years, finding that growth often coexists with stagnation or decline and that both reflection and enactment are needed for sustained professional growth. Huang and Huang (2023) networked the IMPG with the Documentational Approach to Didactics (DAD) to document Chinese teachers 'collective learning through lesson study, proposing an adapted theoretical framework that captures how teachers' collective practice and resource interactions drive professional growth. Most relevant to the present study, Qi et al. (2023) employed a modified version of the Interconnected Model of Teacher Professional Growth (IMTPG) to examine how Chinese mathematics teachers changed their knowledge about authenticity and assessment during a PBL lesson study, demonstrating the framework's applicability in the Chinese PBL context.

Previous research has identified several strengths of the IMPG. First, its non-linear, multi-path structure captures complex, iterative teacher change more effectively than linear models (Vreekamp et al., 2023). Second, the emphasis on reflection and enactment as mediating mechanisms explains how change occurs, not just what changes—a feature that Vlcek and Sedova (2025) highlighted as essential for understanding why some novice teachers experience stagnation rather than growth. Third, as Huang and Huang (2023) and Qi et al. (2023) demonstrated, the IMPG can be productively networked with other theoretical frameworks or modified to address specific research contexts, such as collective learning through lesson study or PBL implementation.

However, previous research has also identified limitations. First, the model's complexity makes it difficult to operationalize; Vreekamp et al. (2023) noted that studies varied widely in how they implemented the IMPG, and Qi et al. (2023) adopted a modified version (IMTPG) to make the framework more manageable for their PBL lesson study context. Second, the model's focus on individual teacher change may under-emphasize social, collaborative, and institutional dimensions of teacher learning, which Huang and Huang (2023) addressed by networking the IMPG with DAD to capture collective resource interactions, and which Qi et al. (2023) acknowledged as a limitation of their modified model. Third, as Vlcek and Sedova (2025) observed, the IMPG does not automatically account for barriers to growth (e.g., limiting beliefs, lack of agency, external barriers), requiring researchers to complement the model with contextual analysis.

Despite these limitations, the IMPG remains a valuable framework for studying dynamic, contextually embedded teacher change processes. In this study, we use the IMPG as an analytical lens to guide our data analysis and interpretation of findings. Specifically, we examine how changes in teachers' personal domain (beliefs and attitudes about PBL) interact with the external domain (expert scaffolding and collaboration), the practice domain (classroom enactment), and the consequence domain (perceived outcomes). This framework informs our analysis of the barriers and facilitators in teachers' PBL competency development.

3. Research Methodology

3.1. Context and Participants

This study focuses on in-service professional development for practicing primary school teachers. To support teachers in effectively embedding PBL into their subject instruction, the design of training content must be aligned with teachers' disciplinary backgrounds and practical instructional needs. Moreover, meaningful competency development requires that professional learning occurs within authentic teaching environments, enabling teachers to construct knowledge through on-site learning, experimentation, and reflection

(Darling-Hammond et al., 2017). Accordingly, this program was structured through a school-university partnership, with training content tailored to the school context and supported by expert coaching embedded in classroom practice. The program was implemented in two main phases (Figure 1). The goal of the first phase was to provide thematic training and guidance on PBL to all participating teachers, while establishing teacher learning communities to facilitate the design, implementation, and evaluation of PBL. The second phase aimed to support teachers in independently designing and implementing new project-based lessons, with gradually reduced external support. To provide teachers with a clear framework for participating in the design and implementation of PBL, this initiative incorporates key elements of lesson study. Lesson study is an inquiry-based, practice-oriented approach to teachers' continuous professional development, characterized by collaborative teacher teams iteratively improving teaching practices through "design-implementation-reflection" cycles while actively incorporating student voice (Win & Kovacs, 2024). Recognizing that lesson study places relatively high demands on teachers' time and resources, we adapted the implementation approach proposed by Takahashi and McDougal (2016), establishing the following core requirements for lesson study: (1) Clearly communicating the objectives and outcomes of both phases; (2) Providing teachers with program materials and encouraging analytical engagement; (3) Facilitating peer exchange based on curriculum design; (4) Supporting implementation, reflection, and discussion based on revised curriculum plans; (5) Involving experts in the iterative refinement of lesson design and implementation; and (6) Organizing teacher-led presentations to share outcomes of their PBL practices.

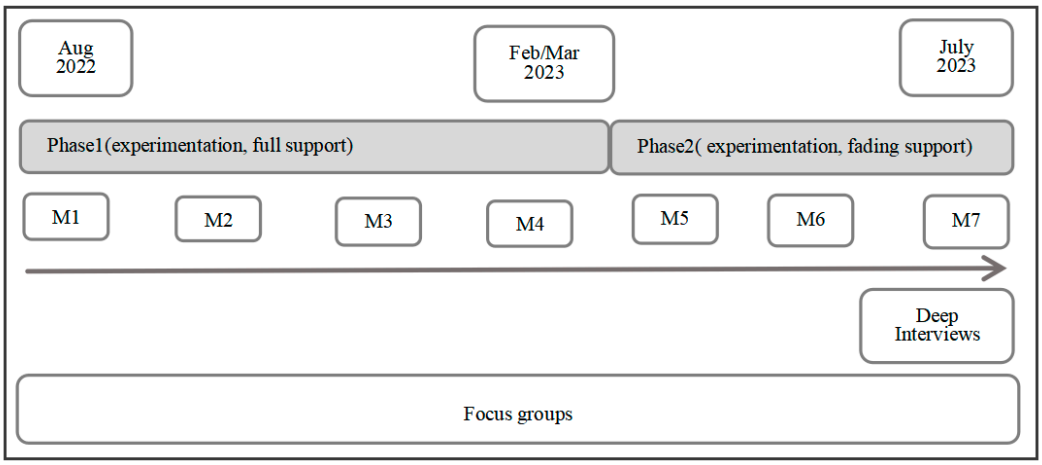


Figure 1. Study design. M2 was workshop training meeting, M3, M4, M6 were meeting about guiding, M1 and M5 were a joint meeting with all six departments together, M7 was presentation meeting.

During the first phase of implementation, a two-day workshop and monthly in-school coaching sessions (each half a day) were held, along with a coordination meeting for all facilitators to discuss the rollout of the project. In the second phase, as external support was intentionally reduced, one joint meeting was organized to address teachers' challenges, followed by one additional in-school coaching session and a final project showcase meeting. It is important to note that, in August 2022, a two-day workshop training was conducted online via Tencent Meeting, which aimed to provide thematic training sessions for teachers and facilitate collaborative design among them, encouraging the implementation of synchronous learning in an online environment. From September 2022 to July 2023, the primary activities were carried out within the school job setting, including lesson implementation, reflection, and expert guidance. Table 1 summarizes the main themes of each session.

Table 1. Overview of the content of the project meetings.

Meeting	Main Topics	PBL Design and Implementation Activities
M1	Introduction to the project foreword; Examine procedural steps for project implementation; Clarify incentives	Clarify teacher collaboration groups
M2	Introduction to PBL theory and methodology; Clarification of project tasks and requirements; PBL case demonstration	Selecting a course topic; Completing a design framework; Practice-based reflection
M3	PBL Core Design Strategy Guide	Constructive Alignment Design Framework; Developing Instructional Strategies and Activities for PBL Implementation; Practice-Based Reflection
M4	PBL Core Implementation Strategy Guide	Provide examples of PBL implementation lessons; Practice-Based Reflection
M5	Linking conference presentations with discussion of PBL design and implementation; Clarifying requirements for PBL success	Practice-based reflection
M6	PBL Design and Implementation Guide	Re-select course topics; Complete and adapt the design framework; Develop instructional strategies and activities for PBL implementation
M7	Linking conference presentations with discussion of PBL design and implementation; Clarifying requirements for PBL success	Reflections based on PBL design and implementation cases

Following the principles of typicality, diversity, and convenience in qualitative sampling, this study recruited participants from eight pilot primary schools involved in the "Project-Based Instruction Aligned with the National Curriculum" professional development program in Nanshan District, Shenzhen, China. This program emphasizes PBL practices grounded in national curriculum standards and requires the design and implementation of PBL to be closely aligned with the nationally mandated subject standards and textbook content. This distinguishes it from project-based approaches that operate independently of formal curricula; instead, it expects teachers to integrate content across disciplines while remaining anchored in national subject objectives. To ensure diversity in terms of subject area, teaching experience, age, and gender, and in coordination with the program administrators, a total of 25 teachers agreed to participate in this ongoing professional development initiative. These teachers had an average age of 33 years (SD = 5.58) and an average of 9 years of subject-specific teaching experience (SD = 6.20). Among them, 24% were male and 76% were female. Subject representation included Chinese Language (24%), Mathematics (36%), English (16%), and others such as Information Technology, Arts, and Mental Health Education (12%). Detailed demographic data are presented in Table 2. The program began in August 2022 and spanned a duration of 12 months. All 25 teachers participated fully in the initiative, during which they each designed and implemented at least two PBL units. Through these experiences, they accumulated varying degrees of success and failure, forming relatively stable conceptions of PBL.

To ensure the rigor and trustworthiness of the thematic analysis, the 25 participating teachers were divided into two subsets: a primary analysis set (n = 20) and a saturation validation set (n = 5). The primary analysis set was used for initial coding, theme development, and framework construction. The saturation validation set was reserved for theoretical saturation testing—specifically, to assess whether additional interviews would generate new codes or themes not already identified in the primary analysis. The five teachers in the validation set were selected using random sampling to ensure

representation. This design decision was made a priori to enable systematic validation of thematic saturation, a practice recommended for enhancing the credibility of qualitative thematic analysis (Proudfoot, 2023).

Table 2. Demographic data of the participants.

Item	Category	Frequency (Percentage)
Gender	Male	6 (24.00%)
	Female	19 (76.00%)
Subject	Chinese	6 (24.00%)
	Mathematics	9 (36.00%)
	English	4 (16.00%)
	Science	3 (12.00%)
	Information Technology, Arts, Mental and Health	3 (12.00%)
Teaching experience	<5 years	6 (24.00%)
	5–10 years	13 (52.00%)
	≥10 years	6 (24.00%)

3.2. Data Collection and Analysis

This study's data were drawn from in-depth teacher interviews and focus groups conducted throughout the project. To triangulate findings, we compared data across three sources: individual interviews, focus groups, and researcher field notes from coaching sessions. Convergence across these sources strengthened the credibility of identified themes. When discrepancies emerged, we examined these differences to refine interpretations. To ensure traceability and transparency of the qualitative data, each quotation in this study is identified by a code in the format [Interview Type]-[School Code]-[Teacher Code]. For example, the code "I2-S3-T2" refers to a quotation from a focus group interview (I2) conducted at School 3 (S3), from Teacher 2 (T2). Specifically:

- Interview Type: I1 indicates in-depth individual interview; I2 indicates focus group interview.
- School Code (S1–S8): Represents the eight pilot primary schools.
- Teacher Code (T1, T2, T3 . . .): A unique identifier assigned to each participating teacher (e.g., T1, T2, T3 . . . T25).

Focus groups came from structured group discussions held during school visits with facilitators and teachers (approximately 60 min each), aimed at reducing the risk of decontextualization arising from individual subjectivity and enhancing the co-constructive and dialogic quality of the data. Specifically, seven focus group sessions were conducted over the 12-month program period, corresponding to the seven meetings outlined in Table 1 (M1 through M7). Participants were grouped by school, with each focus group consisting of 4–6 teachers from the same school to facilitate natural dialogue among colleagues. The focus groups were conducted at key milestones of the program: the introductory meeting (M1), workshop training (M2), coaching sessions (M3, M4, M6), joint meetings (M5), and the final presentation meeting (M7). These group sessions also offered deeper insight into the collective construction of PBL experiences. We drew on the four domains of the Interconnected Model of Teacher Professional Growth (Clarke & Hollingsworth, 2002) to inform the development of our in-depth interview protocol and focus group discussion topics, as well as to guide data analysis.

The in-depth interviews, lasting 60–90 min, were conducted individually with each teacher upon completion of the program. The in-depth interview questions primarily addressed teachers' perspectives on PBL, the evolution of their experiences, the barriers they encountered, and the key factors that supported them in overcoming these barriers. The focus group discussions centered on the challenges and difficulties teachers faced in

designing and implementing PBL, along with the strategies they adopted to address these issues.

The data from in-depth interviews and focus groups were analyzed using thematic analysis, a method for identifying, analyzing, and reporting patterns (themes) within qualitative data. Thematic analysis provides a systematic yet flexible approach, supporting both inductive and deductive reasoning, and enables the exploration of micro-level experiential processes in teachers' project-based practices. The thematic framework presented in Table 3 was developed through a hybrid approach (Proudfoot, 2023; Robinson, 2022). Initial themes were deductively derived from the theoretical framework (IMPG; Clarke & Hollingsworth, 2002) and the PBL teaching competency literature. These initial themes were then iteratively refined and supplemented by emergent sub-themes from open coding of the interview transcripts. The analytical process proceeded as follows:

Table 3. Overview of dimensions, main themes and sub-themes.

Dimensions	Main Themes	Sub-Themes	Definition	Number of Teachers (Percentage)
C1. Teachers' experiences in PBL	B1. Initial concerns and confusion	A1. Initial concerns and confusion	Teachers' reported feelings of uncertainty, worry, or lack of clarity about PBL at the beginning of the program	22 (80%)
	B2. Gradual Recognition and enthusiasm	A2. Gradual Recognition and enthusiasm	Teachers' developing positive attitudes toward PBL as they gained experience	20 (80%)
C2. competency barriers in PBL	B3. Limited cognitive understanding of PBL	A3. Misunderstanding	Teachers' incomplete or inaccurate understanding of PBL concepts	18 (72%)
		A4. Difficulty in knowledge integration	Teachers' challenges in integrating disciplinary knowledge and formulating authentic questions	21 (84%)
		A5. Obstacles in design translation	Teachers' difficulties translating PBL design principles into concrete plans	23 (92%)
	B4. Difficulties adapting to PBL implementation	A6. Disjointed PBL design	Teachers' perception that PBL implementation consists of isolated, unconnected activities rather than an integrated inquiry process	19 (76%)
		A7. Chaotic implementation processes	Teachers' difficulties managing PBL classrooms, including pace, time, space, and role conflicts	17 (68%)
	B5. Negative perceptions of PBL outcomes	A8. Negative emotional overload	Teachers' sustained negative emotional responses to PBL, including frustration, time concerns, and value perception	20 (80%)
		A9. Avoidance psychology	Teachers' lack of self-efficacy and weakened motivation in PBL implementation	18 (72%)
		A10. Behavioral withdrawal	Teachers' observable actions of reducing effort or avoiding PBL implementation	12 (48%)
C3. Key facilitators of PBL teaching competency development	B6. Sustained expert scaffolding	A11.Technical support	External guidance from experts or coaches on PBL design and implementation	24 (96%)
		A12. Diagnosis and assessment	Expert or peer feedback identifying specific problems and suggesting improvements	22 (88%)
		A13. Sustained support needs	Teachers' requirement for ongoing, long-term professional development	25 (100%)
	B7. Practice-oriented teacher collaboration	A14. Collaborative teacher design and implementation	Teachers' collective work in designing, implementing, and reflecting on PBL lessons	23 (92%)

Note: Percentages indicate the proportion of teachers (n = 25) who reported each sub-theme. A single teacher could report multiple themes, so percentages do not sum to 100%.

First, 20 teacher interview transcripts and corresponding focus group discussions were transcribed verbatim and coded using Nvivo 12.0. Through iterative comparison and dialogue between two researchers, 72 initial codes were identified.

Second, based on causal, parallel, and semantic relationships among categories, these were further consolidated into 14 sub-themes, then into 7 main themes and 3 overarching dimensions.

Finally, in-depth analysis, comparison, and synthesis of the core categories were conducted, revisiting the research questions. The core category "Barriers and Facilitators of Teachers' PBL teaching competency" was identified as the central theme connecting all major categories. A logical framework was constructed to illustrate how challenges and enabling factors interact in the development of PBL teaching competency (Figure 2).

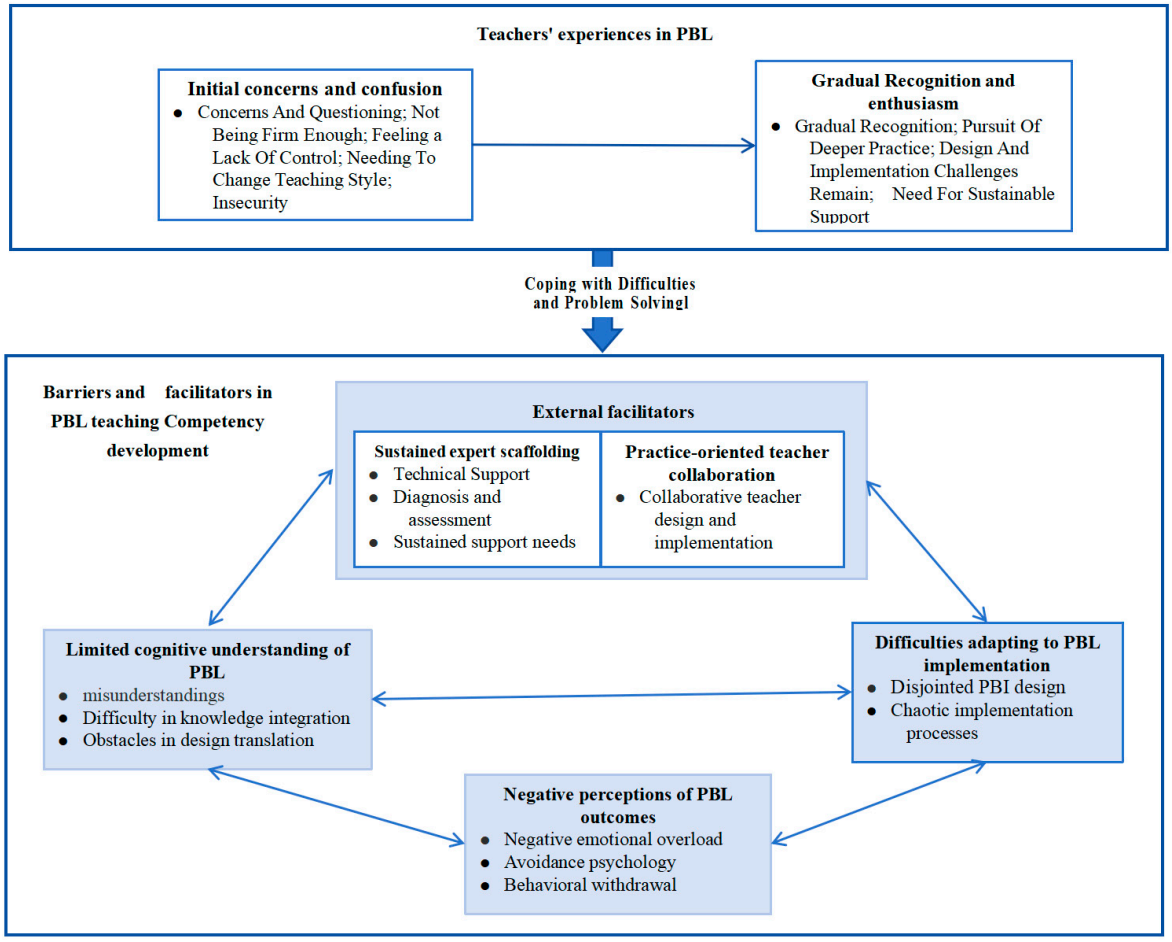


Figure 2. Barriers and facilitators to the development of teachers' PBL teaching competency.

To ensure the reliability and validity of the identified categories, theoretical saturation was tested using the five reserved transcripts (the saturation validation set described in Section 3.1). These five transcripts were analyzed following the same coding procedure applied to the primary analysis set. The analysis revealed no new codes, categories, or relationships beyond those already identified in the primary analysis, indicating that thematic saturation had been achieved and that the coding framework was comprehensive (Robinson, 2022). Therefore, the development of categories was considered complete.

3.3. Researcher Positionality

The authors served dual roles as both designers/facilitators of the professional development program and as researchers analyzing participants' experiences. This dual

role carries interpretive risks, including potential confirmation bias and social desirability effects. To manage researcher subjectivity, we took five steps: (a) developing interview protocols based on the IMPG framework prior to data collection; (b) having research assistants not involved in program design conduct interviews and focus groups; (c) having two researchers code independently, with a third researcher not involved in program design review the coding framework; (d) actively searching for disconfirming evidence; and (e) engaging in reflexive journaling throughout the research process. Despite these precautions, we acknowledge that our dual role may have shaped the research process, and we encourage future research to consider designs where program implementers and data analysts are independent.

4. Results

The constructed conceptual framework (Figure 2) reveals that teachers experienced a process in PBL that evolved from initial concerns and confusion to gradual acceptance and enthusiasm. Throughout this process, teachers faced competency-related challenges in three dimensions: limited cognitive understanding of PBL, difficulties adapting to PBL implementation, and negative perceptions of PBL outcomes. In addressing these challenges, sustained expert scaffolding and practice-oriented teacher collaboration played a critical role in sustaining their engagement with PBL and fostering the development of their teaching competency.

4.1. Teachers from Initial Concern to Gradual Recognition in PBL

In-depth interviews and data from the first phase of focus group discussions revealed that when teachers initially encountered PBL, they often experienced concerns and confusion—questioning whether PBL was truly effective for student learning, how it could be integrated with subject teaching, how to incorporate interdisciplinary content, and how to support student inquiry. For example, one teacher reflected on their first-phase experience:

> I thought I had a good understanding of PBL and tried to incorporate all its essential elements into my teaching—such as higher-order thinking and perfect final products. But the actual teaching process fell far short of my ideal of 'perfection.' The PBL implementation was quite unsuccessful, as both teachers and students were unfamiliar with this approach. (I2-S3-T2, Phase 1)

> When I first approached PBL, I felt like a 'blind person,' often swinging between extremes of blind confidence and complete doubt. I lacked a clear sense of direction and found it very difficult to persist. (I1-S1-T1)

However, in-depth interviews and second-phase focus group findings indicate that as teachers deepened their understanding and practice of PBL, those who had expressed concerns in the first phase began to gradually embrace its principles during the second phase, becoming increasingly enthusiastic about the design and implementation of PBL. For example, teachers reflected on their second-phase experiences:

> At the beginning of my PBL practice, I didn't think too much—I just aimed to complete the task process, and I was satisfied once it was done. But during the second PBL practice, I started focusing on whether the project goals were being achieved, and how to adjust instructional activities to promote student inquiry and goal attainment. I became more intentional about modifying the activity design framework and learning from exemplary practices in other cases. (I2-S2-T2, Phase 2)

> In the second phase, I paid more attention to what innovative projects could be explored and how to implement them more effectively. This was largely built on the relatively successful and complete implementation during the first phase, which was recognized by experts and allowed me to develop my own approach to PBL. (I2-S3-T2, Phase 2)

Nonetheless, despite the growing enthusiasm, challenges and barriers in PBL teaching competency persisted. Over time, these barriers could accumulate and negatively impact teachers' sustained engagement in PBL practice and their capacity development. As noted in the interviews:

> I believe there are still many challenges in the design and implementation of PBL, particularly in constructing driving questions and integrating disciplinary knowledge. (I1-S3-T3)

> I think there are still difficulties in guiding students to conduct deeper inquiry and in how to carry out assessments effectively during PBL implementation. (I1-S4-T1)

4.2. Teacher's Teaching Competency Barriers in PBL

Findings from in-depth teacher interviews indicate that the challenges and barriers teachers face in PBL primarily fall into three interrelated dimensions: limited cognitive understanding of PBL, difficulties adapting to PBL implementation, and negative perceptions of PBL outcomes. These dimensions interact with one another, forming a negative cycle that hinders teachers' effective engagement in project-based practices and the development of their instructional competency.

4.2.1. Limited Cognitive Understanding of PBL Restrict Teachers' Systematic Understanding of PBL Design Logic

Teachers' limited cognitive understanding of PBL manifest in their misunderstanding of the core principles and characteristics of PBL, as well as difficulties in integrating disciplinary knowledge. As a result, they struggle to translate the conceptual foundations of PBL into instructional designs aligned with their subject areas and applicable to their classroom contexts. On the one hand, vague or oversimplified conceptions of PBL negatively impact the quality of design and implementation. In the first phase, teachers often reduced PBL to thematic activity integration, interdisciplinary product exhibitions, or confused project themes with driving questions—thus fragmenting the logical cycle of "problem-driven inquiry–iterative exploration–product presentation." As some teachers expressed during first-phase focus groups:

> PBL is basically unit integration around a theme, linking together a lot of content and letting students do many hands-on activities. (I2-S2-T4, Phase 1)

> My biggest confusion is that I'm not sure whether my understanding is correct. (I2-S2-T4, Phase 1)

On the other hand, although teachers gradually deepened their understanding of PBL's essential features through continued practice, they still struggled with integrating subject content into authentic problem contexts. Analysis of project design plans from both phases revealed that teachers had difficulty approaching curriculum standards and textbook content from a holistic perspective, and in designing driving questions that were grounded in real-world contexts while remaining tightly connected to subject learning goals. This often led to driving questions that were overly broad, abstract, or disconnected from curricular standards. For instance, a teacher noted in an interview:

> I have a certain level of understanding of project-based learning, but it's still very difficult for me to effectively integrate subject curriculum into the design. (I1-S1-T1)

These findings suggest that teachers' conceptual misunderstandings and difficulties in interdisciplinary integration limit their ability to fully grasp the design logic of PBL and raise various obstacles to their design transformation. Consequently, some teachers tended to approach PBL design as a procedural or compliance task—filling out preformatted templates or rigidly applying models without adapting them to their specific instructional context.

4.2.2. Difficulties Adapting to PBL Implementation Weaken the Effectiveness of PBL Implementation

Teachers' difficulties in adapting PBL implementation manifest in their unfamiliarity with the design logic and implementation pathways of PBL, resulting in low adaptability. Analysis of teachers' PBL design plans reveals frequent problems of structural disembedding and disconnection among design elements. For instance, some teachers focus excessively on the final product while neglecting the integration of disciplinary knowledge and thinking; there is a disjointed relationship among learning goals, expected outcomes, assessment, and activity design; learning lacks the guidance of driving questions or a clear progression of scaffolded tasks; and the support structures and resources provided are insufficient to sustain student inquiry and learning. These shortcomings in design lead to "constrained" implementation, where teachers feel unable to proceed smoothly, and in some cases, must interrupt the teaching process or conclude it hastily due to its ineffectiveness. This indicates that poor instructional design exacerbates implementation challenges and leads to further disorganization. As one teacher reflected:

> I usually complete the PBL design before beginning instruction, but when the logic isn't well-formed during design, I feel restricted during implementation. I often think: "This won't work, the next step doesn't connect properly—what should I do?" These concerns arise frequently. As long as the driving questions, task structure, and disciplinary or interdisciplinary knowledge are clearly laid out, implementation runs smoothly. But if these are unclear, it quickly turns into a vague and awkward situation. Immature designs make implementation very difficult. (I1-S3-T3)

Classroom observations and interview data further reveal that influenced by entrenched cognitive habits, many teachers revert to a traditional "introduction–lecture–application" sequence, resulting in teacher-centered instruction. Student thinking remains underdeveloped, and project tasks are often completed only after direct instruction—failing to reflect the PBL principles of "learning by doing," "backward design," or "learning through application." Moreover, since PBL cannot be fully pre-scripted like conventional instruction, many questions and concepts must emerge in real time during class. Teachers often struggle to manage time when discussions extend beyond the plan or when content delivery takes priority over iteration and exploration. This leads to an imbalance—slow pacing in the first half and rushed execution in the second—resulting in a loss of classroom rhythm. In addition, conventional "rows-of-desks" classroom layouts are poorly suited for the multimodal activities required in PBL (e.g., listening, discussion, task work, and online research). Teachers often must rearrange physical spaces or use smart classrooms and coordinate extracurricular learning venues, which imposes extra management burdens. These logistical demands add significantly to the "additional work" required of teachers. Furthermore, role conflicts emerge during implementation. Teachers accustomed to being knowledge authorities struggle to shift into the role of collaborative

facilitators. Many tend to intervene excessively in students' project work, correcting mistakes instead of encouraging exploration—even when they are aware they should step back. One teacher shared:

> When I first implemented PBL, I designed a wide range of activities, but later realized that some did not support task completion and consumed a lot of time. Initially, I asked students to complete most activities during class and have everyone present their results individually, which took up too much time. I started to question whether PBL was wasting students' time—could we really sustain this? During implementation, I also noticed that students were often confused; they didn't know how to work with me or complete their tasks, even though I gave them learning task sheets. Explaining the project requirements also took a lot of time. (I1-S2-T5)

This analysis shows that disjointed PBL design and chaotic implementation processes lead to classroom management difficulties, reinforce teachers' doubts and concerns, and ultimately weaken the effectiveness of PBL.

4.2.3. Negative Perceptions of PBL Outcomes Hinder Teachers' Continued Engagement in PBL

Teachers' negative perceptions of PBL outcomes emerge from the accumulation of difficulties and challenges encountered during implementation, leading to adverse judgments about its value, effectiveness, and sustainability, as well as avoidance-oriented behaviors. Based on analysis of focus groups and in-depth interviews across both phases, it was found that challenges such as unpredictable in-class developments, disrupted pacing, failed project iterations, insufficient resource support, and low student engagement caused teachers to invest significant time and effort in adjusting their PBL plans and managing classroom dynamics. This often resulted in emotional overload—characterized by anxiety, frustration, and a sense of inefficacy—after implementation. In addition, many teachers found it difficult to perceive immediate benefits or efficiency gains from PBL. Influenced by entrenched beliefs in the effectiveness of traditional instructional models for delivering knowledge, teachers expressed concerns about the complexity, time costs, and energy demands of PBL. Some questioned its effectiveness, worrying that students might not develop a solid foundation in core knowledge or might "miss out on important content." To compensate, they often engaged in additional remediation efforts after PBL sessions. Others viewed PBL as misaligned with curriculum standards, arguing that it consumed valuable time for content delivery and undermined the systematic acquisition of disciplinary knowledge. As reflected in teacher interviews:

> One of the most painful things about PBL is having to do so much extra work—designing scaffolds, searching for resources, developing assignments, organizing extracurricular activities, and guiding tasks. With traditional single-period lessons, we just focus on delivering that one class well and we're done. But with PBL, everything is interconnected. Once you do the extra work, the student outcomes are indeed rewarding and often surprising—but all this requires far more time and energy, and I often find it exhausting. Sometimes I just try it once and give up—it's hard to stick with it. (I1-S2-T1)

Especially when teachers lacked a solid understanding of PBL and sufficient external support, their perceived difficulty increased, resulting in heightened anxiety and avoidance. Even teachers with strong interest or initial motivation reported low confidence in managing the complexity of PBL. As shared in interviews and reflective writings:

> I was very resistant and nervous about project-based learning. I saw other teachers' designs fail due to poorly formulated driving questions, and when I tried designing a topic myself, it didn't go well either. I couldn't implement it smoothly and felt deeply frustrated—eventually, I began to avoid PBL altogether. (I1-S5-T2)

> I don't think PBL suits my students. I believe traditional teaching works well—it's direct and efficient. PBL is too complicated, requiring the coordination of too many people and resources. It's too difficult to embed in day-to-day teaching, so trying it once is enough. (I2-S5-T2)

As a result of such persistent negative perceptions of PBL outcomes, some teachers adopted avoidance strategies, such as simplifying project tasks or reverting to lecture-based instruction to regain a sense of control and reduce anxiety. Others externalized the causes of failure, attributing poor outcomes to students' weak academic foundation, parental resistance, lack of support, or resource constraints—rather than reflecting on their own professional competencies in PBL. Some even regarded PBL as a bureaucratic obligation rather than a pathway for pedagogical growth. These negative persistent attitudes and avoidance psychology, which in turn triggered teacher's PBL behavioral withdrawal, including reduced investment in professional development, decreased frequency of implementation, reluctance to revise instructional practices, avoidance of peer discussions related to PBL, and resistance to experimenting with new strategies. Ultimately, this hindered the development of their PBL teaching competency.

A comparison of Phase 1 and Phase 2 data revealed a clear diachronic pattern: in Phase 1, teachers predominantly reported fragmented design and chaotic implementation (A6, A7); by Phase 2, while these barriers persisted, teachers began articulating more sophisticated coping strategies, indicating that later findings scaffolded on earlier difficulties rather than replacing them.

4.3. Key Facilitators Promoting Teachers' PBL Teaching Competency Development

In-depth interview data indicate that the sustained expert scaffolding and practice-oriented teacher collaboration play crucial roles in helping them overcome competency-related barriers in PBL, enabling them to respond to challenges and implement PBL more effectively.

4.3.1. Sustained Expert Scaffolding as a Crucial External Resource for Breaking Barriers to PBL Teaching Competency

Scaffolding from experts bridges the gap between conceptual understanding and classroom practice, offering key external resources to help teachers address difficulties and overcome competency barriers. These supports include technical tools such as templates, exemplary cases, training sessions, formative feedback, diagnostic evaluation, and reflective guidance throughout the PBL design and implementation process. As teachers noted:

> The expert guidance helped me no longer be afraid of PBL. (I1-S1-T1)

> The design template provided by the expert at least showed me how to take the first step. (I1-S2-T1)

> My project on analyzing physical fitness data stalled because students' reports were inaccurate. The expert reviewed the project and student performance and pointed out that there was no structured data categorization or guidance for choosing appropriate analysis methods. They suggested adding data categorization tasks and a discussion component about analysis techniques. (I1-S6-T1)

Teachers also expressed that in Phase 1 they needed clearer task planning, resource support, and full-process expert feedback—from design to implementation to assessment. In Phase 2, they hoped experts could engage earlier, starting from topic selection and continuing through implementation, to reduce self-doubt and adaptation pressure and to provide emotional reassurance. For example:

> When I first encountered PBL, it was most effective when the expert "held our hands" through the PBL design and implementation process." (I1-S4-T1)

> Initially, detailed and directive support from the expert team was very helpful. They tracked the entire process, broke tasks down, and offered targeted lectures and topic diagnostics. That helped me get familiar with PBL quickly. (I1-S3-T1)

> Even though I'm now very comfortable with PBL, I'm still unsure about topic selection and design. I still need an expert to diagnose my plans and help evaluate the implementation. That gives me more confidence. (I1-S5-T2)

These reflections show that although support was scaled back in Phase 2, sustained expert involvement and scaffolding remained vital for designing and implementing PBL.

4.3.2. Practice-Oriented Teacher Collaboration as a Key Factor in Reducing Perceived Difficulty

When designing and implementing PBL independently, teachers often face difficulties such as limited understanding, lack of experience, and inappropriate strategy use. Collaborative planning and execution helped alleviate these challenges. For instance, teachers explained:

> When I designed it alone, I only thought of using surveys. However, after team discussions, we added a drama performance, and students became much more engaged. (I1-S2-T1)

> Knowing our team would review problems together gave me the courage to try more high-risk tasks. (I1-S2-T3)

> I worked with a colleague to improve my task sheet—making the instructions clearer and phrased more student-friendly. It gave students great examples and completely changed their engagement—they became much more proactive. (I1-S1-T2)

In summary, practice-oriented teacher collaboration transforms isolated individual efforts into collective pedagogical innovation. During PBL design and implementation, teachers engage in brainstorming, knowledge exchange, problem-solving, and co-intervention, developing actionable strategies and coping mechanisms. Emotionally, collaboration provides a safe space for trial and error, reducing anxiety and making challenges more manageable—thereby supporting teachers in developing their PBL teaching competency.

5. Discussion

The aim of the research is to examine primary school teachers' experiences in designing and implementing PBL, identify the teaching competency-related barriers they encounter in this process, and explore the key factors that facilitate the development of their PBL teaching competency, which beginning with an emphasis on practice-oriented professional development programs and all participating teachers designed and implemented at least two PBL cases.

5.1. Theoretical Contributions

Returning to the IMPG framework introduced in Section 2.4, we interpret our findings through its four domains—personal, external, practice, and consequence. This study makes several theoretical contributions to the understanding of PBL teaching competency development in high-accountability, centralized educational contexts.

First, our findings reveal that through iterative improvement in PBL design and implementation, teachers acquired substantial knowledge and strategies related to PBL. They also recognized the significant value of this form of professional development for both their own professional growth and student learning. This process led to a shift from initial apprehension to active engagement, gradually fostering teachers' enthusiasm for PBL. This aligns with recent research highlighting the role of teaching practice in promoting teachers' cognitive and strategic development (Vlcek & Sedova, 2025; Vreekamp et al., 2023). However, integrating PBL into routine subject teaching and sustaining its implementation remains a challenge. Most teachers reported that during the first phase, their approach primarily involved imitating others' project practices, and only in the second phase did they begin to develop a deeper understanding of the core concepts and implementation strategies of PBL. Viewed through the IMPG framework, this finding reflects the non-linear, stage-like progression through its four domains—as teachers moved from external input (training) to practice (classroom enactment) to personal domain (belief change) (Clarke & Hollingsworth, 2002; Qi et al., 2023).

Second, our research reveals that despite teachers' growing understanding and increasingly positive attitudes, they still face numerous difficulties and challenges in comprehending and enacting PBL in complex teaching contexts. Teachers commonly identified three interrelated dimensions of competency barriers: limited cognitive understanding of PBL, difficulties adapting to PBL implementation, and persistent negative perceptions of PBL outcomes. These factors formed a self-reinforcing negative cycle, mutually influencing one another and collectively hindering sustained implementation and capability development. Specifically, limited conceptual understanding and challenges with knowledge integration led to decontextualized PBL designs and disordered implementation, which in turn fueled negative perceptions and diminished self-efficacy. This dynamic highlights the non-linear interaction among cognition, behavior, and emotion in the evolving context of PBL, challenging linear models of teacher development focused solely on knowledge or skill acquisition. These results resonate with recent applications of complexity theory in educational change research, which emphasize the need for individuals to continuously adapt and adjust dynamically within ever-changing reform contexts (Huang & Huang, 2023; Zhao et al., 2022).

Third, despite these challenges, teachers gradually gained confidence in overcoming obstacles and continued to develop their PBL teaching competencies—largely driven by sustained expert guidance and effective collaboration. This study highlights the critical importance of sustained expert scaffolding for ongoing PBL practice—especially when experts function not merely as knowledge providers, but as co-practitioners and collaborators. Moreover, our findings point to differentiated roles for experts across developmental stages: in early stages, structured and directive support (e.g., task planning, diagnostic evaluation, reflective guidance) helps lower the barrier to entry; in later stages, experts act as "tracking supporters" who provide longitudinal guidance across the entire project cycle, stabilizing direction and alleviating doubts (Vreekamp et al., 2023; Qi et al., 2023). Furthermore, the study affirms the role of practice-oriented teacher collaboration in advancing PBL, echoing recent findings on professional learning communities and collective teacher efficacy (Huang & Huang, 2023; Zhao et al., 2022). Distinct from purely cognitive-focused knowledge sharing, we emphasize the practice-oriented nature

of collaboration—grounded in co-design, co-teaching, and co-reflection on authentic tasks. Additionally, such collaboration fostered emotional bonds and mutual trust, reinforcing teachers' sense of belonging and enhancing social connectedness.

Fourth, this study extends the IMPG framework by identifying a self-reinforcing negative cycle in teachers' PBL competency development (see Figure 2). While the original IMPG (Clarke & Hollingsworth, 2002) emphasizes the interconnected domains through which professional growth occurs, it does not explicitly theorize how barriers interact to hinder growth. Prior applications of the IMPG (e.g., Qi et al., 2023; Zhao et al., 2022) have focused primarily on growth pathways—how teachers progress through the four domains. Our study complements this literature by illuminating the mechanisms through which teacher change can be blocked, not only facilitated. Specifically, we specify a closed, self-reinforcing loop: limited cognition → implementation difficulties → negative perceptions → further cognitive avoidance. This extension of the IMPG has practical implications: professional development should interrupt this negative cycle at multiple entry points—cognitive (e.g., design templates), instructional (e.g., classroom coaching), and emotional (e.g., peer support).

Overall, our findings both align with and extend the IMPG framework. Consistent with the IMPG, we found that teacher change occurs through non-linear, multi-path interactions among the four domains. However, our identification of a self-reinforcing negative cycle (Figure 2) extends the framework by specifying how growth can be blocked—a dimension under-theorized in the original model. This suggests that the IMPG, while valuable for analyzing growth pathways, may benefit from explicit attention to barriers and their dynamic interactions in future applications.

5.2. Managerial Contributions

Our findings have several practical implications for school leaders, teacher educators, and policymakers who seek to support teachers' PBL implementation and competency development.

For school leaders, this study recommends that continuing professional development should center around PBL lesson study cycles, integrating teachers' emotional adjustment, structured cognitive support, phased expert scaffolding, and effective teacher collaboration to systematically promote teachers' continuous construction of PBL teaching competency through authentic tasks. School leaders should establish dedicated time for collaborative PBL planning and reflection, such as weekly professional learning communities focused on PBL, and facilitate partnerships with university-based experts who can provide sustained, classroom-embedded coaching throughout the entire project cycle. Additionally, creating systems for peer observation and feedback that focus specifically on PBL design and implementation, while recognizing that PBL competency develops over multiple cycles, helps ensure that ongoing support replaces one-time training as the default model of professional development.

For teacher educators and professional development providers, our findings indicate that effective PBL professional development must address cognitive, instructional, and emotional dimensions simultaneously. Rather than offering one-time workshops, professional development programs should provide phased, sustained support that begins with structured guidance—including design templates, exemplary cases, and diagnostic feedback—and gradually shifts toward greater teacher autonomy as competency develops. Programs should also integrate emotional support alongside technical guidance by normalizing the difficulties of PBL implementation and sharing stories of successful persistence. Creating structured opportunities for practice-oriented collaboration—including co-design, co-teaching, and co-reflection on authentic PBL tasks—and using lesson

study cycles as the core organizational structure can further enhance the effectiveness of professional development.

For policymakers, our findings suggest that promoting PBL at scale requires attention to the structural constraints that currently hinder implementation. Policymakers should consider revisiting rigid disciplinary boundaries in curriculum standards to create space for interdisciplinary project-based learning, incorporating process-oriented assessment into formal evaluation frameworks to reduce the exclusive emphasis on high-stakes testing outcomes, and adjusting instructional time allocations to allow for flexible scheduling that can accommodate extended PBL inquiry. Investing in school-university partnerships that provide sustained, classroom-embedded professional development, rather than funding isolated training sessions, represents a more effective allocation of resources for systemic PBL reform.

5.3. Implications for Career Advancement Pathways

The findings of this study also have implications for supporting teachers' career advancement within the education field. The professional development program examined in this study—a 12-month school-university partnership focused on PBL competencies—can serve as a model for structured, competency-based career progression. Specifically, teachers who successfully complete such a program could be recognized as PBL specialists or lead teachers, creating formal advancement pathways within schools or districts. Moreover, the competencies developed through sustained expert scaffolding and practice-oriented collaboration—such as designing authentic projects, facilitating student inquiry, and assessing process-oriented learning—align with the skills needed for instructional coaching or teacher leadership roles. By documenting teachers' growth through competency-based assessments and portfolios, schools can use this program as evidence for promotion or career ladder advancement. Future research should explicitly examine how participation in PBL-focused professional development translates into measurable career outcomes, such as promotion rates, leadership role attainment, or salary advancement.

6. Conclusions

6.1. Key Findings

This study examined Chinese primary school teachers' experiences in designing and implementing PBL, identifying the barriers they encountered and the factors that facilitated their PBL teaching competency development. Three key findings emerge from this study.

First, teachers' experiences in PBL evolved from initial concerns and confusion to gradual recognition and enthusiasm through iterative cycles of design and implementation. However, most teachers reported that deeper understanding of PBL's core concepts and implementation strategies emerged only in the second phase, indicating that competency development requires multiple cycles of practice.

Second, teachers faced interconnected competency barriers across three dimensions: limited cognitive understanding of PBL (misunderstanding, difficulty in knowledge integration, obstacles in design translation); difficulties adapting to PBL implementation (disjointed design, chaotic implementation processes); and persistent negative perceptions of PBL outcomes (emotional overload, low confidence, behavioral withdrawal). These barriers formed a self-reinforcing negative cycle that hindered sustained engagement.

Third, sustained expert scaffolding and practice-oriented teacher collaboration served as key facilitators. Experts played differentiated roles across developmental stages—providing structured, directive support in early stages and acting as tracking supporters in later stages. Practice-oriented collaboration, grounded in co-design, co-teaching, and co-reflection on authentic tasks, also fostered emotional bonds and mutual trust.

In summary, these findings illuminate not only what teachers achieved programmatically (outputs), but also how their professional learning evolved (learning outcomes) and what may sustain or hinder their long-term engagement (postulated impacts).

6.2. Limitations and Future Research Directions

Several limitations of this study should be acknowledged. First, regarding transferability, this study was conducted with 25 teachers drawn from eight pilot primary schools in Shenzhen, an economically developed urban area with relatively abundant educational resources. The findings may not be directly generalizable to rural or less-developed regions where teachers face different constraints, such as larger class sizes, fewer resources, and limited access to expert support, nor to international contexts with different educational systems and cultural norms. Future research should examine PBL implementation across diverse Chinese contexts, including rural schools, to assess the transferability of these findings.

Second, regarding data sources, this study relied primarily on self-report data from teacher interviews and focus group discussions. While these methods are appropriate for capturing teachers' subjective experiences and perceptions, they do not provide direct evidence of classroom practices or student outcomes. We did not conduct systematic classroom observations to triangulate teachers' reported experiences with observed teaching behaviors. Consequently, the findings reflect what teachers said they did and experienced, which may not fully align with their actual classroom practices due to factors such as social desirability bias or limitations in recall. Future research could complement our findings with longitudinal quantitative studies tracking changes in teachers' PBL competency over time, as well as incorporating multiple data sources including classroom observations and student surveys.

Third, regarding researcher positionality, the authors served dual roles as both program designers and analysts of participant experiences. This dual role may introduce interpretive bias, as the researchers' prior involvement might influence their interpretation of interview data. To manage this bias, we took several steps: interview protocols were developed based on the IMPG framework prior to data collection; coding was conducted independently by two researchers; a third researcher not directly involved in program design reviewed the coding framework; and we actively searched for disconfirming evidence in the data, including teachers' expressions of difficulty and withdrawal. Despite these precautions, the potential for bias remains. Future research should consider designs where program implementers and data analysts are independent.

Fourth, our data collection spanned 12 months, capturing teachers' experiences across two PBL phases. Professional growth in PBL teaching competency likely continues beyond this timeframe. Future research should employ longer-term longitudinal designs (e.g., 3–5 years) to examine how PBL competencies evolve over extended periods and how initial support structures influence long-term sustainability.

Fifth, this study focused on teacher-level barriers and facilitators. School-level and system-level factors—such as principal leadership, school culture, district policies, and national curriculum reforms—were not the primary focus of our analysis. Future research should examine how these broader contextual factors interact with teacher-level processes, perhaps through multi-level or mixed-methods designs.

Sixth, while our study identified negative emotional responses (e.g., anxiety, frustration, low confidence) as significant barriers, we did not systematically investigate interventions specifically targeting these emotional dimensions. Future research should explore whether emotional support interventions—such as peer coaching, reflective writing, or emotion-

focused professional development—can mitigate negative emotional responses and promote sustained engagement with PBL.

6.3. Concluding Remarks

This study provides rich, contextualized insights into the barriers and facilitators shaping Chinese primary school teachers' PBL teaching competency development. The findings underscore that meaningful PBL implementation requires sustained, multi-dimensional support addressing teachers' cognitive, instructional, and emotional needs simultaneously. Accordingly, continuing professional development should center around PBL lesson study cycles, integrating emotional adjustment, structured cognitive support, phased expert scaffolding, and effective teacher collaboration to systematically promote teachers' continuous development of PBL teaching competency through authentic tasks.

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Institutional Review Board Statement: This research adhered to the ethical principles of the Helsinki Declaration (1975, amended 2008). All data collected are primary qualitative data obtained directly from participants through interviews and focus groups. The data were anonymized through coding, with no identifying information retained. Informed consent was obtained from all participants prior to data collection. Therefore, formal ethical approval was not required by Shaanxi Normal University for this low-risk qualitative study.

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