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Optimizing Problem-Solving Skills in Pedagogical Content Knowledge for Prospective Madrasah Ibtidaiyah Teachers

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Abstract

Problem-solving competence is crucial for prospective Madrasah Ibtidaiyah teachers in making instructional decisions. This study examined the influence of project-based learning on problem-solving skills within Pedagogical Content Knowledge (PCK) and identified supporting and inhibiting factors in a civic education instruction course. An embedded mixed-method design was applied to 46 prospective Madrasah Ibtidaiyah teachers at Universitas Islam Lamongan. Quantitative data were gathered through the Problem-Solving Inventory and problem-solving skills within the PCK test dimension. These data were analyzed using the Wilcoxon Signed Rank Test, effect size, and N-gain. Qualitative data from observations, interviews, and documentation were thematically analyzed. Results indicated that project-based learning significantly enhanced problem-solving skills ($p = 0.000$), with a medium effect size (0.697) on the Problem Solving Inventory and a large effect size (0.87) on PCK. However, the N-gain score was relatively low (0.27). Qualitative findings reinforced these results, highlighting contextual learning, collaboration, critical thinking, systematic planning, reflection, lecturer support, resource availability, and field experience as enablers. At the same time, group dynamics, coordination with school teachers, and students' initial readiness acted as barriers. This study underscores the potential of project-based learning to bridge theory and practice while fostering problem-solving skills among prospective Madrasah Ibtidaiyah teachers. Its novelty lies in exploring project-based learning across planning, implementation, and reflection, which represent enacted PCK (ePCK) within the Refined Consensus Model, as well as integrating collective PCK (cPCK) as content knowledge. Future research should involve larger samples, design project-based pedagogical modules, and examine long-term effects on both ePCK and cPCK development.

Keywords: Problem-solving skills, civic education instruction, project-based learning, pedagogical content knowledge, prospective Madrasah Ibtidaiyah teachers.

Abstrak

Keterampilan pemecahan masalah penting bagi calon guru Madrasah Ibtidaiyah dalam pengambilan keputusan instruksional. Penelitian ini mengeksplorasi pengaruh pembelajaran berbasis proyek terhadap keterampilan pemecahan masalah dalam dimensi Pedagogical Content Knowledge (PCK), serta faktor pendukung dan penghambat implementasinya pada mata kuliah Pembelajaran Pendidikan Kewarganegaraan. Metode yang digunakan adalah mixed method embedded design dengan melibatkan 46 mahasiswa calon guru Madrasah Ibtidaiyah di Universitas Islam Lamongan. Data kuantitatif dikumpulkan melalui Problem Solving Inventory dan tes keterampilan pemecahan maslaah dalam

dimensi PCK, dianalisis dengan Wilcoxon Signed Rank Test, effect size, dan N-gain. Data kualitatif dari observasi, wawancara, dan dokumentasi dianalisis secara tematik. Hasil menunjukkan pembelajaran berbasis proyek berpengaruh signifikan (p = 0.000) terhadap peningkatan keterampilan pemecahan masalah, dengan effect size sedang (0.697) pada Problem Solving Inventory dan besar (0.87) pada dimensi PCK, meskipun skor N-gain rendah (0.27). Faktor pendukung meliputi pembelajaran kontekstual, kolaborasi, berpikir kritis, perencanaan sistematis, refleksi, dukungan dosen, ketersediaan sumber daya, dan pengalaman lapangan, sedangkan penghambat mencakup dinamika kelompok, koordinasi dengan guru sekolah, dan kesiapan awal mahasiswa. Temuan menegaskan peran pembelajaran berbasis proyek dalam menjembatani teori dan praktik sekaligus mengoptimalkan keterampilan pemecahan masalah calon guru. Kebaruan penelitian terletak pada eksplorasi pembelajaran berbasis proyek dalam ranah perencanaan, pelaksanaan, dan refleksi yang merepresentasikan enacted PCK (ePCK) dalam kerangka Refined Consensus Model, serta integrasi collective PCK (cPCK) sebagai muatan materi. Penelitian selanjutnya disarankan melibatkan sampel lebih luas, mengembangkan modul pedagogik berbasis proyek, dan mendalami dampak intervensi terhadap perkembangan cPCK dan ePCK.

Kata Kunci: Keterampilan pemecahan masalah, pembelajaran pendidikan kewarganegaraan, *project-based learning*, *pedagogical content knowledge*, calon guru Madrasah Ibtidaiyah

INTRODUCTION

Civic education instruction course in Madrasah Ibtidaiyah faces complex challenges that require prospective teachers to possess pedagogical capacities beyond mere content mastery. Civic education instruction course not only teaches knowledge about citizens' rights and responsibilities but also emphasizes the development of democratic attitudes, participatory skills, and decision-making abilities in social life (Hämäläinen and Nivala, 2023; Wahidah and Suharno, 2025). This complexity demands that prospective teachers in Madrasah Ibtidaiyah are able to design learning that is contextual, participatory, and adaptive to diverse classroom dynamics.

In addressing these challenges, problem-solving skill becomes an essential competence for prospective Madrasah Ibtidaiyah teachers. This ability enables teachers to analyze learning situations, formulate innovative solutions, and critically reflect on their practices (Altun, 2019; Shanta and Wells, 2022). Prospective teachers with strong problem-solving skills are better prepared to face real issues in civic education instruction courses, such as low student participation or difficulties in understanding social issues, while also fostering critical and reflective thinking skills in their students (Y. Huang, 2022; Ocak, 2018; Sudrajat et al., 2023). Prospective teachers can improve their ability to make instructional decisions through careful learning planning (Chen and Zhang, 2019; Zaragoza et al., 2021).

In addition to problem-solving skill, prospective teachers need to master Pedagogical Content Knowledge (PCK), which integrates knowledge of civic education content with effective teaching strategies (Saubern et al., 2019; Shulman, 2015). Within the Refined Consensus Model (RCM), enacted PCK (ePCK) represents the practical implementation of PCK in teaching practice through three main dimensions: plan, teach, and reflection reflection (Carlson and Elliott, 2019; Neumann et al., 2019).

However, the learning practices of prospective teachers at the Civic Education Instruction Course, Universitas Islam Lamongan, still show limitations. The course primarily

emphasizes content mastery through presentations and question-and-answer sessions, whereas simulation-based learning or real-case analysis remains minimal. Preliminary study results indicate that 69% of students have low problem-solving skills, while only 31% are categorized as high. This condition indicates a gap between the need for problem-solving skills and the instructional interventions implemented.

Project-Based Learning becomes a relevant alternative to explore its effect on problem-solving skills of prospective teachers in Madrasah Ibtidaiyah within the enacted PCK dimensions (Son and Lee, 2020). One potential learning model is Project-Based Learning, which involves students in solving authentic problems and producing concrete products (Santrock, 2018). The theoretical foundation of Project-Based Learning intervention refers to Polya's problem-solving framework and Dewey's educational philosophy. Polya (1973) emphasizes four stages of problem-solving: understanding the problem, devising a plan, carrying out the plan, and looking back, which align with the ePCK dimensions of plan, teach, and reflection. Dewey asserts that meaningful learning emerges through direct experience (learning by doing) and critical reflection (Ulrich, 2016).

Previous studies have highlighted problem-solving skill in the context of elementary teacher education. Alberto and Vega (2018)examined problem-solving skill in a mathematical context, but their focus was limited to curriculum patterns and evaluation without linking to pedagogical dimensions. Saputro et al. (2019) emphasized the effect of problem-based learning on academic outcomes but did not integrate these skills with prospective teachers' pedagogical practice. Similarly, Son and Lee (2020) investigates the correlation between conceptual understanding and problem-solving ability, but does not include pedagogical learning interventions. Similarly Rini and Purwanti (2021) and Koç and Elçi (2022) showed that implementing specific learning models could enhance problem-solving skill, yet the emphasis remained on content rather than teaching skill.

There remains a research gap concerning how instructional interventions can simultaneously enhance prospective teachers' problem-solving skill and strengthen their PCK, particularly in the enacted dimension. Kinay and Bagceci (2016) highlighted that this gap is evident from the limited experimental studies comparing different instructional methods to enhance problem-solving skill. Barendsen and Henze (2019) added that studies on PCK in real teaching contexts are still underexplored.

Based on this gap, this study offers novelty by exploring the effect of Project-Based Learning on problem-solving skill of prospective teachers in Madrasah Ibtidaiyah within the planning, teaching, and reflection dimensions, representing enacted PCK within the Refined Consensus Model, while also integrating collective PCK as content. Therefore, this study aims to analyze the effect of Project-Based Learning on problem-solving skill of prospective teachers in the Civic Education Instruction Course and to identify factors influencing its effectiveness. The study is expected to strengthen problem-solving skill and pedagogical competence of prospective teachers, while enriching teacher education practices based on PCK in higher education.

RESEARCH METHODS

Research Design

This study adopted a mixed-methods approach with an embedded experimental design to investigate the impact of project-based learning on enhancing problem-solving skills within the PCK dimension. The intervention was conducted over eight sessions, spanning eight weeks from September to October 2024. Each session was aligned with the syntax of project-based learning, the four stages of problem-solving, based on Polya's (1973) Framework—understanding the problem, devising a plan, carrying out the plan, and looking back—and the enacted PCK (ePCK) framework, which includes planning, instruction, and reflection (Alonzo et al., 2019, p. 274; Carlson et al., 2019). The conceptual alignment of these elements is illustrated in Figure 1.

The learning intervention involved real-classroom teaching scenarios centred on Civic Education topics. Students engaged in problem diagnosis in elementary schools, designed lesson plans, developed instructional tools, and reflected on their teaching practices. This project-based learning intervention differed from previous conventional instruction by emphasising authentic school-based projects, collaborative inquiry, and structured reflection.

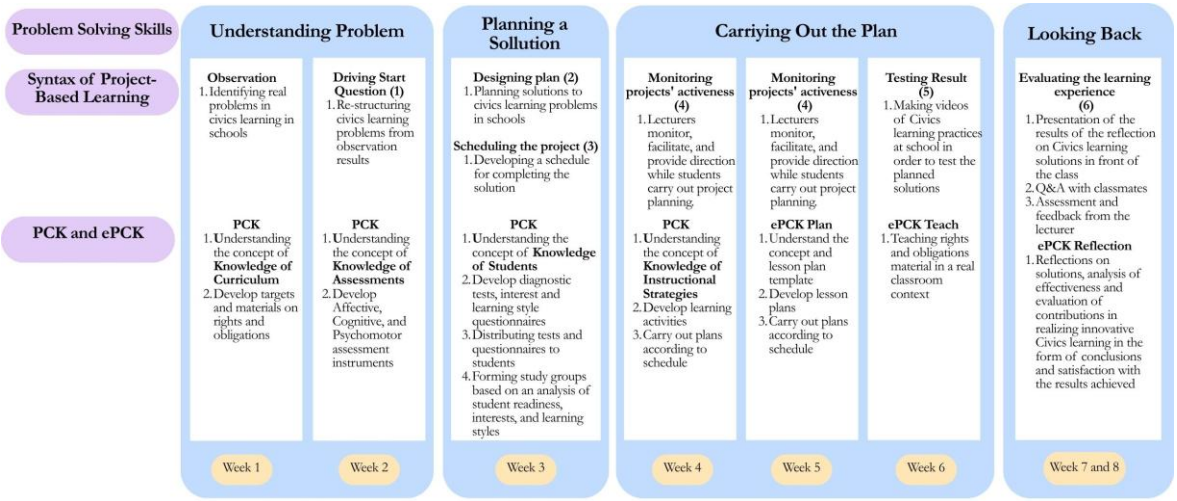

Figure 1. Implementation Map of Project-Based Learning to Enhance Problem-Solving Skills within the PCK Dimension

Participants

A total of 46 fifth-semester students enrolled in the Civic Education instruction course at Lamongan Islamic University in the 2024/2025 academic year participated in the study. The quantitative sample was selected using a saturated sampling technique, consisting of the entire student population in the course. Of these, 8.7% were male and 91.3% were female. Based on the Problem-Solving Inventory (PSI), 78% of students were categorised as having low problem-solving skills, and 22% were categorised as high. For the qualitative phase, purposive sampling was used to select ten students representing both high and low problem-solving skill levels. Selection criteria included PSI classification, level of engagement during project work, and willingness to participate in interviews.

Instruments

The assessment of problem-solving skills was conducted using the Problem-Solving Inventory, initially developed by Heppner and Petersen (1982). The instrument included 31 items that demonstrated strong validity and reliability ($\alpha = 0.833$) and was rated on a six-point Likert scale, from 1 ('strongly agree') to 6 ('strongly disagree'). Based on (Karabacak et al., 2015), scores were classified into high (32–80) and low (81–192) categories.

Problem-solving skills within the PCK dimension were assessed using a scenario-based open-ended test, validated by two experts. The test prompted students to respond to Civic Education teaching cases by identifying the problem, proposing instructional strategies, and evaluating outcomes. Responses were scored using a rubric based on Polya's model, refined by Salazar-Torres et.al. (2021), with indicators aligned to the phases of ePCK. Results were categorised into novice (1.00–2.33), apprentice (2.34–3.67), and proficient (3.68–5.00), based on (Andrade et al., 2020).

Semi-structured interviews explored participants' experiences with project-based learning and their perceived growth in problem-solving abilities within the context of Civic Education instruction. The interview guide was validated by two specialists in project-based learning and teacher education. Interviews were held in a quiet campus setting, each lasting approximately 30 to 45 minutes.

Collection and Analysis of Data

Pretest and posttest data were collected via Google Forms. Data normality was tested using the Kolmogorov–Smirnov test. As the data were non-normally distributed, the Wilcoxon Signed Rank Test was used to analyse differences (Suyono, 2018). The Normalised Gain Score (Hake, 1998; Nissen et al., 2018) measured learning improvement, while the effect size was calculated using Cohen's formula (Cohen, 2018) to determine the strength of the intervention.

Qualitative data were analysed thematically using Creswell's (2018) five-step procedure: transcription, initial reading, coding, theme development, and narrative reporting. NVivo 15 was used to manage coding and theme organisation. Member checking was conducted to confirm the credibility of participants' responses, and peer debriefing was used to validate coding consistency.

The researcher served as both instructor and facilitator, and also acted as an internal observer throughout the intervention. To ensure implementation fidelity and minimise bias, two expert observers were assigned to independently monitor the application of project-based learning syntax during each session. To reduce researcher bias, reflective notes were kept during the analysis process.

RESULTS AND DISCUSSION

Findings

The Influence of Project-Based Learning on Problem-Solving Skills

The findings show that the implementation of project-based learning significantly enhanced students' problem-solving skills, both in general and within the PCK dimension. Instruments were administered before and after the intervention. The results of the Problem-Solving Inventory (PSI) indicated a significant improvement in students' overall problem-

solving ability after the implementation of project-based learning. Before the intervention, 36 students were categorised as low and only 10 as high. After the intervention, the number of students in the high category increased to 33, while those in the low category decreased to 13 (see Figure 2). The mean PSI score improved from 85.41 (low) to 79.30 (high). Since the pre-test data were non-normally distributed ($p = 0.010$) and the post-test data were normally distributed ($p = 0.083$), the Wilcoxon Signed-Rank Test was employed, revealing a statistically significant difference ($Z = -4.730$, $p < 0.001$). The effect size of 0.697 indicates a moderate impact on the development of problem-solving skills (Table 1).

Qualitative findings reinforced these results. Many students reflected that project-based learning helped them become more confident and systematic in solving problems. For example, Participant 13 stated: "We explored real problems through classroom observations and interviews with teachers and students, which helped us understand the issues more concretely." These narratives illustrate the shifts captured in the PSI, confirming that engagement in authentic projects contributed to students' growing self-regulation and confidence in problem-solving.

Figure 2. Student Distribution by Problem-Solving Inventory Levels Before and After Project-based Learning

Table 1. Statistical Analysis of Problem-Solving Inventory Scores and Problem-solving Skills in the PCK dimension: Normality Test, Wilcoxon P-Value, and Effect Size

	Normality		Inferential Statistics		Effect size	N-Gain
	Pre	Posts	Z Score	Sig. (2-tailed)		
Problem-solving inventory	0,010	0,083	-4,730	0,000	0,697	
Problem-solving skills in the PCK	0,126	0,001	-5,906b	0,001	0,87	0,27

Source: Primary data from the research

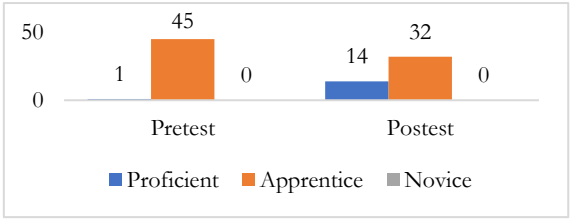

Figure 3 . Student Distribution by Problem-Solving Skills Levels within the PCK Dimension (Pretest and Posttest)

In addition to general problem-solving, significant gains were observed in students' problem-solving skills within the Pedagogical Content Knowledge (PCK) dimension. Before the intervention, most students were in the Apprentice category (78.3%), while only 4.3% were classified as Proficient. After the intervention, 41.3% advanced to Proficient, with no students remaining in the Novice category (Figure 3). The average score rose from 3.06 (SD = 0.25) to 3.56 (SD = 0.36). The Wilcoxon Signed-Rank Test confirmed a significant difference between pre- and post-test scores ($Z = -5.906$, $p < 0.001$). The effect size was large (0.87), suggesting a strong influence of project-based learning. However, the N-gain was relatively low (0.27), which can be attributed to students' moderate initial scores that left less room for improvement (Table 1).

Student reflections supported these quantitative findings. For instance, Participant 46 commented: "We developed solutions after analysing the problems and adapted them to the resources available in the school." This shows how the planning and implementation processes helped translate their understanding into practical solutions, consistent with the rise in scores across all four indicators.

Table 2. Descriptive Statistics of Each Problem-Solving Skill Indicator in PCK Dimensions Before and After Project-Based Learning

Dimension	N	Pretest		Posttest	
		Mean	SD	Mean	SD
Understanding Problem	46	3,04	0,36	3,56	0,42
Planning a Solution	46	3,12	0,34	3,67	0,46
Carrying Out the Plan	46	3,03	0,53	3,51	0,48
Looking Back	46	3,047	0,36	3,57	0,39

Source: Primary data from the research

These gains were reinforced by shifts in the distribution of student ability levels (Figure 4). Before the intervention, most students fell into the Novice and Apprentice categories, with very few classified as Proficient. After project-based learning, substantial progress was evident. As shown in Table 2, the mean score for understanding the problem increased from 3.04 to 3.56, indicating a shift from predominantly Novice and Apprentice levels to Proficient (Figure 4). Table 3 further indicates a statistically significant improvement ($Z = -5.377$, $p < 0.001$), with a medium effect size (0.79) and an N-gain of 0.26 (low). While the normalized gain suggests gradual progress, the medium effect size highlights a meaningful pedagogical impact of the intervention.

Qualitative data provided further explanation of this gain. Participant 13 reflected, "We explored real problems through classroom observations and interviews with teachers and students, which helped us understand the issues more concretely." Similarly, several students emphasized that authentic school engagement made them more confident in identifying core problems rather than simply repeating textbook formulations. These insights suggest that

project-based learning enhanced their diagnostic ability by bridging abstract theoretical perspectives with observable realities in the classroom.

Figure 4. Student Distribution by Problem-Solving Skill Levels (PCK Dimension) Before and After Project-Based Learning

Table 3. Inferential Statistics of Each Problem-Solving Skills Indicator within the PCK Dimension

Dimension	Normality		Inferential Statistics		N-Gain	Effect Size
	Pre	Post	Z	Sig. (2-tailed)		
Understanding Problem	0,001	0,024	-5,377	<0.001	0,26	0,79
Planning at Solution	0,001	0,039	-5,406	<0.001	0,28	0,79
Carrying Out the Plan	0,001	0,176)	-4,324	<0.001	0,2	0,64
Looking Back	0,001	0,001	-5,730	<0.001	0,26	0,84

Source: Primary data from the research

Building on this, *Planning a Solution* showed the strongest overall increase. Mean scores rose from 3.12 to 3.67 (Table 2), and the Wilcoxon analysis confirmed a significant difference ($Z = -5.406$, $p < 0.001$), with a medium effect size (0.79) and the highest N-gain among all indicators (0.28) (Table 3). The number of students at the Proficient level increased markedly, from 2 to 19 (Figure 4). These results indicate that students made the most progress in developing strategies to address problems once they had been clearly identified.

Qualitative narratives reinforce this trend. Participant 46 explained, "We developed solutions after analysing the problems and adapted them to the resources available in the school." This demonstrates that students did not merely propose generic solutions, but tailored

their approaches to contextual constraints. Taken together, the data suggest that project-based learning nurtured more systematic and context-sensitive planning abilities, as reflected in both the quantitative gains and qualitative insights.

In contrast, the indicator of *Carrying Out the Plan* showed more modest progress. The mean score increased from 3.03 to 3.51 (Table 2), and the inferential results (Table 3) revealed a statistically significant improvement ($Z = -4.324$, $p < 0.001$), with a medium effect size (0.64) and the lowest N-gain among all indicators (0.20). The number of Proficient students grew from 5 to 13 (Figure 4). This indicates that while students improved in implementing their solutions, the progress was less pronounced compared to other stages.

Qualitative findings help explain this result. Participant 34 remarked, "I learned how to manage time, work in teams, and prioritise tasks more effectively." Others highlighted challenges in coordinating group tasks and balancing time demands, which likely limited the normalized gains. Nevertheless, the improvement in scores combined with qualitative reports shows that students acquired valuable experiential skills in collaboration, organization, and responsibility—skills essential for actual classroom practice, though perhaps more difficult to capture through tests alone.

Finally, *Looking Back* demonstrated the most substantial alignment between quantitative and qualitative findings. Mean scores improved from 3.04 to 3.57 (Table 2). The Wilcoxon test confirmed a significant difference ($Z = -5.730$, $p < 0.001$), with the largest effect size observed (0.84, large) and an N-gain of 0.26 (Table 3). The number of Proficient students increased from 0 to 12 (Figure 4), indicating a major shift in reflective capacity.

Qualitative reflections strongly support these statistical results. Students emphasized that the reflection phase allowed them to critically evaluate both successes and shortcomings. Participant 34 explained, "Presenting our projects and writing reflections made me think about what worked and what needed improvement." Other students reported that structured reflection not only consolidated their learning but also motivated them to adjust their strategies for future teaching practice. These findings suggest that Looking Back was the most transformative indicator, fostering a mindset of continuous improvement that is crucial for professional growth.

The integration of results is summarised in Figure 5. The PSI data demonstrate that project-based learning improved students' general problem-solving ability, while the PCK-based analysis reveals how these gains manifested across the four stages: Understanding the Problem, Planning a Solution, Carrying Out the Plan, and Looking Back. Notably, reflection (Looking Back) carried the highest weight because students consistently engaged in reflection at each stage of the process, reinforcing its transformative role. Conversely, Understanding the Problem lagged behind other stages, as students still faced challenges in problem diagnosis despite authentic engagement.

Together, these findings show that project-based learning not only strengthened students' problem-solving confidence and regulation (as captured in the PSI), but also enhanced their pedagogical capacity to diagnose, plan, implement, and reflect on solutions in Civic Education contexts (as captured in the PCK dimension).

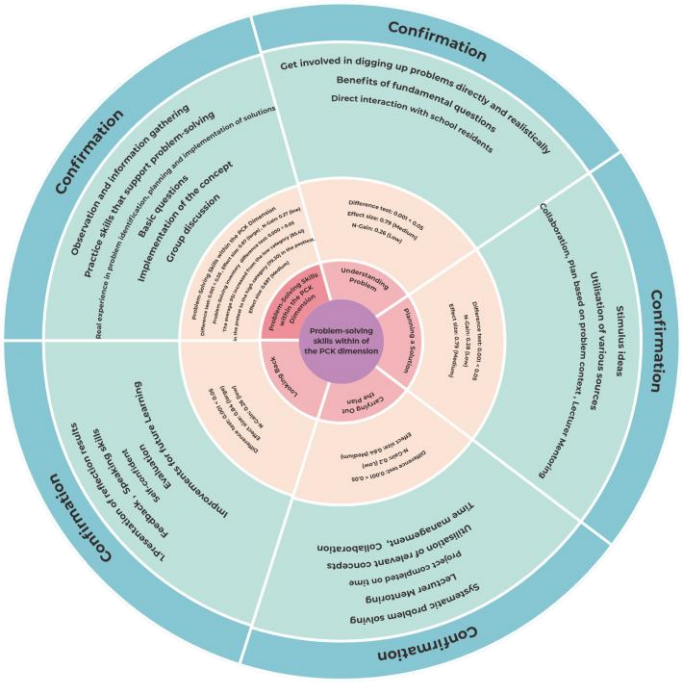

Figure 5. Integration of Quantitative and Qualitative Results

Factors that Influence the Implementation of Project-based Learning in Optimising Problem-Solving Skills within the PCK Dimension

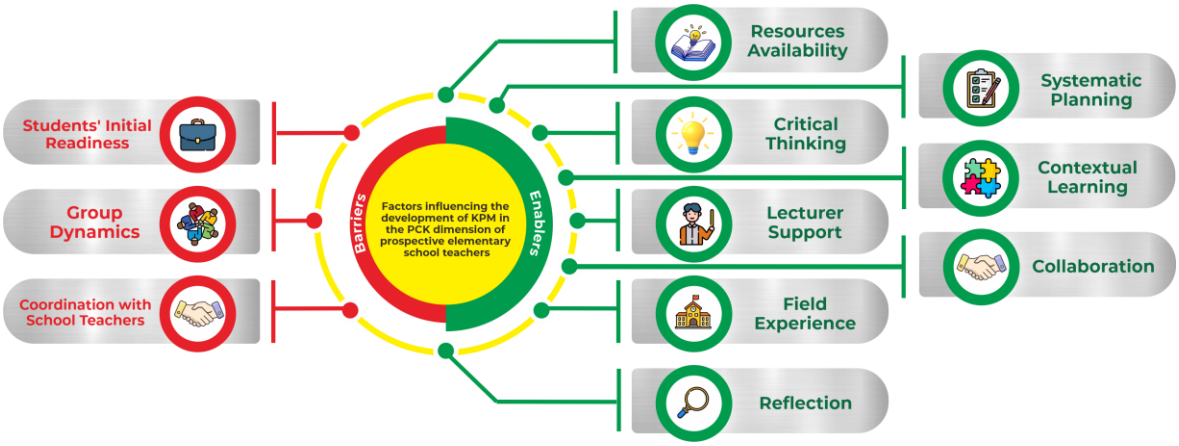

Figure 6. Enablers and Barriers in the Development of Problem-Solving Skills within the PCK Dimension

The qualitative data revealed that the development of problem-solving skills within the PCK dimension among prospective Madrasah Ibtidaiyah teachers was shaped by both enablers and barriers during the implementation of project-based learning in the Civic Education instruction course, as illustrated in Figure 6. This visualization is further supported by coding tables (Tables 4 and 5), which trace the analytical process from open coding to selective coding.

Table 4. Coding Categorization of Enablers

Open Coding (Field Data)	Axial Coding (Sub-category)	Selective Coding (Enablers)
"We applied theories to solve real problems in schools."	Engagement with authentic challenges	Contextual Learning
"Project-based learning made us more active and collaborative."	Teamwork and social interaction	Collaboration
"I had to find information and develop a creative way…"	Analytical and innovative thinking	Critical Thinking
"Everyone had a responsibility in the project…"	Structured task distribution and time use	Systematic Planning
"We evaluated what worked and what didn't."	Self-assessment and evaluation	Reflection
"Lecturers guided us and gave feedback."	Academic supervision and mentoring	Lecturer Support
"We had access to journals, online tools, and social media."	Access to varied instructional resources	Resource Availability
"Seeing Civic Education classes firsthand helped us identify real problems."	Direct classroom observation	Field Experience

As presented in Table 4, eight enablers were identified as critical to the development of problem-solving skills. Contextual learning was the most prominent, as students engaged directly with authentic challenges in elementary classrooms. As Participant 31 noted, "We did not just learn theories; we applied them to solve real problems in schools." Collaboration was another essential enabler, enabling students to negotiate ideas, co-construct solutions, and share responsibilities. Participant 15 reflected, "Project-based learning made us more active and collaborative in creating learning solutions." Critical thinking also developed as students analyzed learning needs, explored alternatives, and designed contextually appropriate strategies. Participant 32 shared, "I had to find information and develop a creative way to address the challenges we observed."

Systematic planning and time management ensured timely project completion and accountability. Participant 36 remarked, "Everyone had a responsibility in the project, so no tasks were missed." Reflection further allowed students to evaluate the effectiveness of their solutions and refine their approaches. As Participant 32 stated, "We evaluated what worked and what didn't, and that shaped how we think about solving problems."

Other enablers included lecturer support, with consistent guidance and formative feedback throughout the project. Participant 27 explained, "Lecturers always gave feedback every week, so we knew what needed to be improved in our project." The availability of diverse resources—ranging from academic journals to online platforms and even social media such as TikTok and Instagram—also inspired innovative instructional designs. Participant 18 commented, "We searched for ideas from journals and social media, and even TikTok and Instagram helped us find new ways to design learning materials." Finally, field experiences provided students with valuable opportunities to observe Civic Education practices firsthand

and identify real instructional challenges. Participant 36 reflected, "Seeing Civic Education classes firsthand helped us identify real problems to solve."

Tabel 5. Coding Categorization of Barriers

Open Coding (Field Data)	Axial Coding (Sub-category)	Selective Coding (Barriers)
"Some group members were passive."	Unequal roles in teamwork	Group Dynamics
"It was difficult to coordinate with school teachers."	Communication and scheduling constraints	Coordination with School Teachers
"I had never faced real classroom problems in previous courses."	Lack of prior exposure	Students' Initial Readiness

Meanwhile, Table 5 highlights three major barriers that constrained the effectiveness of project-based learning. The first was group dynamics, where unequal participation among members often created unbalanced workloads. As one student stated, "Some group members were passive, so the workload was carried mostly by a few people."

The second barrier involved coordination with school teachers. The tight schedules of classroom teachers often limited opportunities for students to engage in discussion or receive feedback. As one participant explained, "It was difficult to coordinate with school teachers because their schedules were very full."

The third barrier concerned students' initial readiness. Many students were unfamiliar with solving authentic classroom problems, which created challenges at the beginning of the project. Participant 14 acknowledged, "At first, I felt confused because I had never faced real classroom problems in previous courses."

Discussion

The Influence of Project-Based Learning on Problem-Solving Skills

This study demonstrates that the implementation of project-based learning significantly enhances the problem-solving skills of prospective Madrasah Ibtidaiyah teachers, both in general and within the PCK dimension. The observed improvement is supported by measurements using the Problem-Solving Inventory and an analysis of problem-solving skills in the PCK dimension. These findings align with previous studies by (Rehman et al., 2024), which found project-based learning to act as a mediator in mathematical problem-solving, and Singh (2024), who reported significant improvement in applied physics problem-solving abilities. Other studies have also confirmed the effectiveness of project-based learning in developing problem-solving skills in both general contexts (Arrieta-Cohen et al., 2024; M et al., 2024) and computational settings (Choi and Yang, 2024).

Furthermore, this research reveals that the implementation of project-based learning fosters students' ability to identify and analyse problems in civic education. Through field observations aimed at mapping learning challenges and analysing the central question, "How can your group help schools implement innovative civic education?", students were trained to

systematically and contextually examine root problems. This approach aligns with Odeh and Patanakul (2024), who emphasised the importance of evaluating real-world project situations before formulating solutions. The findings also support studies by Fitzpatrick et al. (2019) and Alsmadi et al. (2024), which highlighted that engagement in real-world issues promotes conceptual relevance and enhances problem-solving skills.

Students' success in understanding problems was also supported by the constructivist approach underlying the implementation of project-based learning. Learning based on real-world experience, interaction with the environment, and lecturer guidance as scaffolding supports the cognitive development process (Piaget, 1969; Rahmat et al., 2021; Vygotsky, 1978; Zheng, 2021). As a result, students who initially struggled with problem formulation were able to develop their capacity. Completing project tasks also led to increased self-confidence and self-efficacy (Bandura, 1997; Marley et al., 2022).

In the solution design aspect, project-based learning effectively trained students to create lesson plans relevant to real-world contexts. In the design phase, students developed solutions to address civic education problems in the form of tangible products. During this process, they directly applied PCK concepts within the project context. This result aligns with findings from Guizado et al. (2024) dan Pazildzhanova (2024), who stated that project-based learning fosters conceptual understanding and complex planning skills among pre-service teachers. Flexibility in determining instructional strategies and adapting to school conditions illustrates the integration between content and pedagogy. The lecturer's role as a facilitator of reflection strengthened students' strategic decision-making skills (Abidin et al., 2023; L. Wang and Oliver, 2022; Yanti et al., 2024). In this context, students faced non-routine challenges and were motivated to explore new teaching approaches (Ergen, 2020; Güner and Erbay, 2021; Saygili, 2017).

Students' ability to implement the designed plans also improved, as observed during the monitoring and testing stages of project-based learning. They developed and executed a project schedule that culminated in a lesson plan, which was then piloted through direct teaching in schools (ePCK Teach). This finding aligns with the perspectives of Berry et al. (2016) dan Gess-Newsome et al. (2019), who argued that content knowledge, when integrated with pedagogical skills, strengthens the teacher's professional framework. Similar support comes from Kshetree (2023) and Pamintuan (2024), who emphasised the importance of integrating PCK to produce contextual and effective teaching strategies.

Project-based learning also contributed to the development of students' managerial skills, such as time management, collaboration, and project accountability. These competencies were developed through project implementation, which required distributing tasks and completing them according to a set schedule. This aligns with the principle of sustained inquiry, which demands that students investigate problems in depth and continuously (Larmer et al., 2015), thus strengthening critical thinking and self-management. The findings are supported by research demonstrating that project-based learning enhances conceptual understanding and problem-solving abilities (L. A. Duiseyeva and S. M. Bazhenova, 2024; Wani et al., 2025; Zhao, 2024). Project exploration and execution also foster 21st-century skills (Peña et al., 2024) and create meaningful learning through direct experiences (Sousa, 2024). Lecturers play a critical

role in aligning these activities with the principle of critique and revision (Larmer et al., 2015), ensuring that students not only complete the project but also reflect meaningfully on it.

The reflection aspect was prominent in students' ability to revisit the learning solutions they had developed. The evaluation phase of project-based learning provided students with an opportunity to review the process, assess the effectiveness of their solutions, and design more relevant improvements for the future. Presentations and group discussions provided platforms for sharing experiences, challenges, and innovations. This process reinforced continuous learning cycles (Hamidah et al., 2020) and underscored the importance of reflection as part of the inquiry process in project-based learning (Larmer et al., 2015). These findings align with Shulman's (1986, 2015) integrative PCK concept, asserting that effective teachers not only understand content but also reflect on instructional practices within specific contexts. Students reported that feedback from lecturers and peers was instrumental in refining their strategies, boosting confidence, and designing more relevant solutions. The public product principle of project-based learning, which emphasises sharing projects openly, also increased motivation and satisfaction (Larmer et al., 2015).

Overall, the implementation of project-based learning has proven to promote the active and reflective development of students' problem-solving skills, as emphasised by Wahyudiati et al. (2022) and Abilova et al. (2024) through meaningful activities. Although studies on the relationship between project-based learning and PCK development remain limited, these findings are consistent with previous research indicating that project-based learning enhances teachers' self-directed and reflective learning capabilities (Poonputta, 2023; Zarouk et al., 2020). The recorded increase in the proficient category also aligns with J. Wang (2024), who stated that reflection strengthens novice teachers' ability to bridge the gap between theory and practice.

These findings suggest that project-based learning has a significant impact on enhancing students' problem-solving skills within the PCK dimension, as indicated by the substantial intervention effect. However, the relatively low gain scores suggest limited growth potential, especially since most participants already possessed moderate initial abilities. Hake (1998) stated that participants with an intermediate entry level tended to show proportionally smaller gains. Furthermore, the effectiveness of project-based learning in developing in-depth problem-solving skills requires a sufficient learning duration (Musna et al., 2021; Upadhye et al., 2022), which was not fully met in the context of this study.

Furthermore, the short intervention period likely restricted students from exploring problems deeply and reflectively. Project-based learning demands continuous inquiry processes, ideally facilitated through longer learning cycles (Thomas, 2000). Additionally, the use of open-ended tests as assessment tools, although effective in evaluating critical and creative thinking, has limitations in capturing incremental progress in learning. This supports Nilimaa (2023) findings that traditional and open assessments often fail to reflect the complexity of the learning process. Grover et al. (2016) also, it emphasised that evaluating open-ended tasks requires more flexible formative approaches to capture students' actual achievements. Without process-oriented assessments, as suggested by Winne (2023), conceptual progress may remain undetected.

To address these limitations, this study complemented quantitative data with qualitative data through interviews, observations, and documentation. This mixed-methods embedded

experiment approach enabled the researchers to gain a more holistic understanding of the students' learning process and outcomes, especially those not fully captured by written tests (Creswell, 2018). The approach also provided a richer context (Birkeland et al., 2024; Pessoa and Mitchell, 2025) for understanding the dynamics of problem-solving development within the PCK dimension during project-based learning implementation. Thus, qualitative data functioned not only as a complement but also as a means to capture the internalisation of knowledge and students' reflective processes more deeply.

Conceptually, the findings enrich the Refined Consensus Model (RCM) of PCK (Carlson and Elliott, 2019), particularly in integrating collective PCK (cPCK) and enacted PCK (ePCK). These findings underscore the importance of experientially-based training to enhance the application of PCK in teaching practice (Chan and Yung, 2018; Galimova et al., 2023). Practically, the study fills a gap in the literature on implementing context-based PCK, which has been underexplored (Barendsen and Henze, 2019).

Factors that Influence the Implementation of Project-based Learning in Optimising Problem-Solving Skills within the PCK Dimension

The successful implementation of project-based learning in developing prospective Madrasah Ibtidaiyah teachers' problem-solving skills within the PCK dimension is influenced by eight key enablers. First, the connection between theory and real-world practice served as the foundational element for the effectiveness of project-based learning. Students were provided opportunities to bridge theoretical concepts with field contexts through school- and community-based learning experiences. This process enriched their conceptual understanding while training them to identify problems, formulate solutions, and design context-relevant instructional actions (Rachmadyanti et al., 2025; Thomas, 2000). These findings align with experiential learning theory (Kolb, 2015), which emphasises the transformation of experience as the core of the learning process.

Second, group collaboration significantly contributed to the enhancement of problem-solving skills within the PCK dimension. Collaborative discussions promoted the principle of "voice and choice," in which students shared roles and perspectives when designing solutions for civic education instruction. This collaboration not only improved social skills but also strengthened students' ability to make decisions based on logical and relevant arguments (Larmer et al., 2015; Sukmawati et al., 2019). Third, critical and creative thinking skills played a key role in the problem-solving process. Students were trained to explore various alternative solutions through debate and reflective discussions focused on real classroom contexts. These abilities were fostered through active involvement in inquiry processes and the contextualization of complex problems (Thomas, 2000).

Fourth, systematic planning and managerial skills further supported the successful implementation of Project-based learning. Students demonstrated the ability to develop project schedules, divide roles and responsibilities proportionally, and implement instructional solutions grounded in learned concepts. This process required adequate time and resource management, consistent with the assertion by Stanojević Gocić and Petković (2018) that sound planning and management are key to successful project execution.

Fifth, critical reflection emerged as an essential component in developing problem-solving skills. Through reflective processes, students evaluated the effectiveness of their instructional strategies and identified opportunities for improvement. This activity encouraged continuous refinement and contextual adjustment of their approaches. Deep reflection has been shown to support the development of higher-order thinking, including analytical skills and strategy adjustment (Abilova et al., 2024; Hartmann et al., 2023; Salehi, 2018).

Sixth, lecturer support served as an important enabling condition. Lecturers consistently provided feedback and guidance throughout the project cycle, ensuring that students remained aligned with course objectives. This mentorship also facilitated the development of professional identity and the confidence to apply instructional innovations in classroom contexts (Handayani et al., 2024; Kamruzzaman, 2023; Yilmaz, 2022; Zhang et al., 2024).

Seventh, resource availability enhanced the creative and practical aspects of project work. Access to diverse instructional resources—including academic journals, online platforms, and social media—empowered students to design instructional products that were innovative and relevant to civic education. Fitri et al. (2024) emphasised that technological access enriches the process of information-seeking and content design in project-based learning environments.

Eighth, field experience offered authentic exposure to elementary classroom practices. Students were able to observe real civic education instruction, diagnose existing challenges, and craft solutions relevant to the school context. This authentic engagement not only validated their theoretical knowledge but also strengthened their instructional PCK (Anagün, 2018; Anazifa and Djukri, 2017). Previous studies confirm that authentic environments facilitate deeper problem-solving and the development of practical teaching innovations (Festiyed et al., 2018).

Despite these enabling factors, the implementation of project-based learning also faced three barriers. The first was group dynamics, where unequal participation and commitment sometimes undermined collaboration. Lawless and Gosselin (2023) noted that differences in communication styles and conflict resolution approaches directly affect project success, while Licorish et al. (2024) emphasised that variations in initiative and responsibility can hinder optimal outcomes.

The second barrier was coordination with school teachers. Limited consultation opportunities due to scheduling conflicts created a gap between theoretical preparation and classroom realities. Asghar et al. (2024). highlighted that insufficient communication weakens access to meaningful insights, while Abas (2016) and Lim (2021)pointed to administrative challenges and difficulties in building effective school relationships.

The third barrier was students' initial readiness. Limited prior exposure to project-based learning reduced confidence and adaptability, especially among students accustomed to traditional approaches. Meng et al. (2023) and Tain et al. (2023)observed that such students often struggle with autonomy, while Servant-Miklos dan Kolmos (2022) confirmed that understanding of project-based methods is shaped by earlier experiences, making authentic engagement essential for developing relevant problem-solving skills.

CONCLUSION

This study demonstrates that project-based learning significantly enhances the problem-solving skills of prospective Madrasah Ibtidaiyah teachers, both generally and within the PCK dimension, particularly in Civic Education Instruction Courses. This finding highlights the potential of project-based learning to bridge theory and practice in teacher education. Moreover, it supports the development of Islamic educational values, such as ijtihad, shura (deliberation), and amanah, by embedding authentic projects into the curriculum.

The study also identified key factors influencing the success of project-based learning. Enabling factors included contextualized learning, collaboration, critical thinking, systematic planning, reflection, lecturer support, resource availability, and field experience. In contrast, barriers such as group dynamics, coordination with school teachers, and students' initial readiness affected the overall effectiveness of the intervention. The integration of quantitative and qualitative findings confirms that project-based learning is effective in real classroom contexts.

Based on these findings, it is recommended that educators implement project-based learning beginning with case-based simulations to strengthen students' initial readiness. The projects should be designed around authentic elementary school problems integrated with PCK and ePCK, and supported by team management training, group contracts, and peer assessment to minimize group dynamics barriers. In addition, pre-service teachers should receive training in the effective use of observation and interview instruments to help them gather deeper insights from classroom teachers.

This study has limitations related to the relatively small sample size (46 participants) and the short intervention duration (eight weeks). Future research should involve larger and more diverse samples, extend the intervention across a full semester to allow deeper engagement and reflection, develop systematic and contextualized project-based pedagogical modules, and evaluate the impact of interventions on ePCK and cPCK. Addressing these aspects will strengthen the generalizability and practical relevance of project-based learning in Islamic prospective teacher education.

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