

Leveraging Lesson Study to Develop Technological Pedagogical Content Knowledge in Pre-Service Teacher Education

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ABSTRAK

Program Pendidikan Profesi Guru prajabatan dirancang sebagai wahana strategis untuk menyiapkan calon guru yang profesional dan kompeten. Namun dalam praktiknya masih terdapat tantangan, terutama dalam mengintegrasikan teknologi, pedagogi, dan konten secara terpadu dan konsisten selama kegiatan praktik mengajar. Penelitian ini bertujuan untuk menganalisis implementasi Lesson Study serta mengkaji kontribusinya terhadap pengembangan Technological Pedagogical Content Knowledge (TPACK) pada mahasiswa calon guru. Penelitian menggunakan pendekatan studi kasus kualitatif dengan melibatkan mahasiswa calon guru dan dosen pembimbing sebagai partisipan. Data diperoleh melalui observasi pembelajaran, wawancara mendalam, serta analisis dokumen berupa rencana pembelajaran dan refleksi mengajar. Analisis data dilakukan dengan teknik analisis tematik melalui tahapan pengkodean, pengelompokan kategori, dan penafsiran makna. Temuan menunjukkan bahwa Lesson Study membentuk kerangka kolaboratif yang mendorong perencanaan bersama, dialog reflektif, dan perbaikan pembelajaran secara berkesinambungan. Peningkatan kompetensi TPACK tampak dari perubahan penggunaan teknologi yang awalnya bersifat sederhana menjadi lebih terintegrasi dengan strategi pedagogis dan substansi materi. Secara keseluruhan, Lesson Study efektif dalam memperkuat kompetensi TPACK calon guru. Implikasinya, penerapan Lesson Study dalam program pendidikan profesi dapat menjadi strategi sistematis untuk meningkatkan mutu praktik pembelajaran, menumbuhkan budaya refleksi profesional, serta mempersiapkan guru yang adaptif dan responsif terhadap dinamika pendidikan abad ke-21.

ABSTRACT

The Pre-Service Teacher Professional Education Program is designed as a strategic initiative to prepare prospective teachers to become competent and professional educators. However, in practice, it continues to face challenges, particularly in integrating technology, pedagogy, and content in a coherent and consistent manner during teaching practicum. This study aims to analyze the implementation of Lesson Study and examine its contribution to the development of Technological Pedagogical Content Knowledge (TPACK) among pre-service teachers. The research employed a qualitative case study approach involving pre-service teachers and supervising lecturers as participants. Data were collected through classroom observations, in-depth interviews, and document analysis of lesson plans and teaching reflections. Data analysis was conducted using thematic analysis through coding, categorization, and interpretation. The findings indicate that Lesson Study establishes a collaborative framework that promotes joint planning, reflective dialogue, and continuous instructional improvement. The enhancement of TPACK was reflected in the shift from basic technology use toward more integrated alignment between pedagogical strategies and subject content. Overall, Lesson Study proved effective in strengthening pre-service teachers' TPACK competencies. The implications suggest that integrating Lesson Study into professional education programs can serve as a systematic strategy to enhance instructional quality, foster a culture of professional reflection, and prepare adaptive teachers who are responsive to the evolving demands of 21st-century education.

1. INTRODUCTION

Education serves as the fundamental foundation for the development of human resources and the advancement of a nation, as it shapes individuals not only in cognitive aspects but also in character, skills, and life values (Adadi et al., 2024; Kusuma et al., 2025). The quality of educational implementation is largely determined by the quality of teachers as the primary actors in the classroom learning process. Professional teachers are not only expected to master subject matter but also to possess strong pedagogical competence, adaptability to technological developments, and a commitment to continuously improving their instructional practices. In the context of 21st-century education, which is characterized by digital transformation and increasingly complex learner needs, the role of teachers has become more strategic and demanding, requiring the integration of content knowledge, pedagogy, and technology in a coherent manner (Banarsari et al., 2023; Majdi, 2023). Therefore, improving teacher quality has become a crucial agenda in educational reform, as the effectiveness of learning and students' academic achievement ultimately depend on teachers' competence and professionalism.

Teacher quality is universally recognized as a key determinant of student achievement. In the 21st-century educational landscape, teachers are expected not only to master content and pedagogy but also to integrate digital technologies effectively into their instruction. This has led to the increasing emphasis on the development of Technological Pedagogical Content Knowledge (TPACK), a comprehensive framework that combines content expertise, pedagogical strategies, and technological fluency to improve teaching and learning outcomes. In the Indonesian context, improving teacher quality has become a national priority. One of the key initiatives addressing this issue is the Teacher Professional Education (TPE) program, which is designed to prepare pre-service teachers to meet high professional and educational competency standards (Mardhatillah & Surjanti, 2023; Soenarto et al., 2021). As part of its pedagogical training, the TPE program incorporates various instructional approaches, among which Lesson Study (LS) has emerged as a particularly effective method (Aryanti et al., 2024; Hrastinski, 2021). Lesson Study is a collaborative, cyclical process that involves joint planning, teaching (or observation of an open class), reflection, and revision of teaching practices among educators (Al-Hattami & Bawaneh, 2024; Rodrigues & Arroio, 2020). This model not only fosters reflective practice but also enhances pedagogical decision-making through shared expertise and continuous improvement cycles.

However, the empirical reality in many educational settings still shows a considerable gap between these expectations and actual classroom practices. Although teacher professionalism is formally emphasized in policy and curriculum documents, many teachers continue to experience challenges in translating integrated knowledge into effective instructional practice. The integration of content, pedagogy, and technology is often partial rather than holistic, with digital tools used merely as presentation aids instead of as instruments for meaningful learning transformation (Darsih et al., 2023; Sonsupap et al., 2024). Lesson planning frequently remains procedural and compliance-oriented, focusing on the completion of required documents rather than on designing engaging, student-centered learning experiences. In pre-service teacher education, including professional preparation programs, candidates may demonstrate theoretical understanding of pedagogical concepts but struggle to enact them coherently during teaching practice. Collaborative reflection and systematic feedback are not always optimally implemented, limiting opportunities for deep professional growth. These conditions illustrate that, despite the growing emphasis on TPACK and innovative instructional models, the practical realization of these frameworks in authentic classroom contexts is still inconsistent (Sonsupap et al., 2024; Suryana et al., 2021). Consequently, there remains an urgent need for structured, reflective, and collaborative mechanisms within teacher education programs to bridge the gap between normative expectations (*das sollen*) and the actual conditions of teaching practice.

A growing body of research supports the effectiveness of Lesson Study in improving pre-service teachers' pedagogical knowledge and classroom practices. Several studies have specifically highlighted the potential of LS to contribute significantly to the development of TPACK among future educators (Rodrigues & Arroio, 2020; Türk & Baki, 2024). A clear relationship has been found between enhanced TPACK understanding and improved student learning outcomes in science education (Muzaini, 2023; Suryana et al., 2021). In addition, LS has been reported to promote 21st-century competencies such as reflective thinking, creativity, and teaching confidence (Kurt & Sezek, 2021; Sholeh, 2023). Further benefits include improved lesson planning, strengthened noticing skills the ability to observe and interpret critical classroom interactions, and increased collaboration among prospective teachers (Kihwele & Mwamakula, 2023; Phuong, 2024). These benefits illustrate the compatibility between LS and the goals of modern teacher education.

Besides, previous research has demonstrated the potential of Lesson Study in enhancing instructional practices, fostering professional collaboration, and improving reflective teaching (Rozimela,

2020; Susetyarini et al., 2024). In the context of teacher education, several previous studies have shown that Lesson Study can facilitate pedagogical improvement among pre-service teachers (Sonsupap et al., 2024; Türk & Baki, 2024). Similarly, TPACK has been widely adopted as a theoretical framework to assess teachers' integrated knowledge in using technology effectively (Darsih et al., 2021; Kasi et al., 2022). Some local studies in Indonesia have begun to explore the intersection between Lesson Study and TPACK development, but findings remain fragmented, and few offer in-depth analyses within the formal structure of the PPG program. Despite its potential, the implementation of Lesson Study within the TPE program is not without challenges. Existing studies have noted obstacles such as low motivation, limited institutional support, time constraints, difficulty in preparing for Open Class, and even seclusion behavior among pre-service teachers (Azmi et al., 2024; Sugiati & Damayanti, 2023). Moreover, while both LS and TPACK have been independently studied in the Indonesian context, there is a lack of integrated research that explores how Lesson Study directly supports TPACK development within the formal structure of the TPE program.

This study offers a clear element of novelty by systematically integrating Lesson Study with the development of Technological Pedagogical Content Knowledge (TPACK) within the formal structure of Indonesia's Teacher Professional Education (PPG) program. While previous research has examined Lesson Study and TPACK separately, and some have explored their intersection in limited contexts, few studies have provided an in-depth analysis of how Lesson Study can function as a structured, cyclical mechanism to intentionally strengthen pre-service teachers' integrated technological, pedagogical, and content knowledge. This research moves beyond descriptive accounts by analyzing not only outcomes but also the implementation process, enabling factors, and contextual challenges within the institutional framework of the PPG program. By positioning Lesson Study as a strategic and embedded professional learning model rather than a stand-alone intervention, the study contributes a more coherent and context-sensitive understanding of how collaborative planning, classroom enactment, and reflective dialogue can concretely enhance TPACK development. In doing so, it bridges theoretical constructs with practical teacher preparation processes and proposes a sustainable model for strengthening teacher competence in the digital era.

This study aims to address the existing research gap by providing an in-depth analysis of the role of Lesson Study in enhancing Technological Pedagogical Content Knowledge (TPACK) among pre-service teachers enrolled in Indonesia's Teacher Professional Education (PPG) program. Specifically, the study examines how Lesson Study is implemented within the TPE program, identifies key factors that influence its successful implementation such as collaborative engagement, mentoring practices, and institutional support and analyzes how Lesson Study contributes to the development of pre-service teachers' TPACK competencies. By focusing on the processes of collaborative planning, classroom enactment, and reflective practice, this study offers a comprehensive understanding of how Lesson Study supports pre-service teachers in integrating technology, pedagogy, and content in a more coherent and reflective manner during their teaching practice.

2. METHOD

This study employed a qualitative approach with a case study design to explore in depth the implementation of Lesson Study (LS) within the context of the Teacher Professional Education (TPE) program in Indonesia. The case study design allows for a holistic understanding of the phenomenon in its real-life context, particularly how LS is integrated into the Field Practice (PPL) component of the PPG, as mandated in the official TPE implementation guidelines. To address the research objectives, this study employed multiple qualitative instruments to generate rich and triangulated data. Data were collected through classroom observations, semi-structured interviews, and document analysis. Classroom observations were guided by an observation protocol focusing on the stages of Lesson Study (planning, teaching, and reflection), patterns of collaboration among lecturers, and pre-service teachers, as well as the enactment of teaching practices. Semi-structured interviews with pre-service teachers, and lecturers were conducted to explore factors influencing the successful implementation of Lesson Study, including collaborative engagement, mentoring support, reflective practice, and institutional conditions such as time and resource availability. In addition, document analysis was carried out on teaching artifacts, including lesson plans, using an analysis checklist to examine the development of pre-service teachers' TPACK competencies, particularly the alignment of technology, pedagogy, and content across Lesson Study cycles. This combination of instruments enabled a comprehensive understanding of both the process and impact of Lesson Study within the PPG program.

The participants of this study consisted of, PPG pre-service teacher candidates who were actively undergoing their PPL while implementing Lesson Study as part of their professional teaching development, and supervising lecturers who played a key role in mentoring and facilitating the LS process.

This study was approved by the Teacher Education Institutions, therefore the participants were selected from five Teacher Education Institutions or *Lembaga Pendidikan Tenaga Kependidikan* (LPTK) across Indonesia, representing diverse geographical and institutional contexts. Each institution contributed a group of five student-teacher participants, resulting in a total of 25 PPG students involved in the study. In addition, at least one supervising lecturer from each institution actively involved in the mentoring and implementation of Lesson Study was included, making the total number of participants 30 individuals. Informed consent was obtained from all individual participants included in the study. Purposive sampling was employed to ensure that participants met specific criteria, such as active participation in Lesson Study cycles during Field Practice, availability of documented teaching practices, and willingness to engage in reflective interviews and observations.

This participant composition was considered sufficient to provide varied perspectives while maintaining depth of inquiry within each institutional case. Data in this study were collected through three complementary primary instruments. First, in-depth interviews were conducted with student-teachers and supervising lecturers to obtain comprehensive insights into their experiences, perceptions, and challenges in implementing Lesson Study. Second, participant observation was carried out by directly observing the entire Lesson Study cycle during the teaching practicum (PPL), including lesson planning meetings, open class sessions, and reflective discussions. Third, document analysis was undertaken by reviewing various instructional artifacts produced by the student-teachers, such as lesson plans, digital learning materials, teaching reflections, and institutional documents related to the implementation of Lesson Study. This triangulated data collection approach enabled a comprehensive understanding of both the process and outcomes of LS implementation within the PPG framework. The data were analyzed using a thematic analysis technique carried out through several systematic stages. First, coding was conducted by identifying key units of meaning from interview transcripts, observation notes, and related documents. These initial codes were then organized through a categorization process, in which similar codes were grouped into broader thematic categories based on recurring patterns and their relevance to the research questions. Finally, the interpretation stage involved synthesizing the emerging themes to generate meaningful insights, particularly concerning the development of TPACK and the factors influencing the implementation of Lesson Study.

3. RESULT AND DISCUSSION

Result

The Teaching Practicum (PPL) is implemented as an integrated system alongside several theoretical courses. It is conducted throughout the duration of the PPG program, specifically during the first and second semesters. The practicum follows a clinical supervision approach, involving guidance from professionals such as the University Supervisor and the Mentor Teacher. The PPL adopts the Lesson Study model to train pre-service teachers in engaging in continuous reflective practice. The PPL course (PPL I and II) facilitate pre-service teacher education program (PPG) students as prospective teachers to develop and strengthen their competencies in understanding learners; the learning process and environment; designing, implementing, and evaluating contextual learning; as well as making professional decisions. Competence development is carried out gradually through the following stages: (1) Orientation, (2) Observation of both academic and non-academic environments, (3) Assisting mentor teachers in conducting classroom instruction, (4) Reviewing and designing lesson plans together with the mentor teacher to implement guided teaching, followed by evaluation and reflection on the implemented teaching and conducting follow-up actions for subsequent improvements, and (5) Final reflection discussion of the PPL program.

In this study, the implementation of Lesson Study (LS) was integrated into the PPL course across five teacher education institutions (LPTKs) in Indonesia. The LS model, which emphasizes collaborative planning, peer observation, and reflective discussion, was adopted to strengthen the professional learning experience of PPG students. Through the stages of Plan, Do, and See/Reflect, pre-service teachers had the opportunity to design lessons collaboratively with lecturers and mentor teachers, practice teaching in real classrooms, and engage in reflective dialogue to identify strengths and areas for improvement. This integration allowed students to not only practice the technical aspects of lesson delivery but also to develop critical and reflective thinking skills essential for continuous professional growth. The implementation of Lesson Study within the PPL course is closely embedded in the practice of guided teaching. In this context, pre-service teachers (PPG students) conduct teaching practice under the intensive guidance of mentor teachers and/or university supervisors. Each student is required to complete a minimum of three cycles of guided teaching practice. Each cycle of teaching practice encompasses the following stages: (1) preparing lesson plans and learning materials (Plan), (2)

implementing the teaching practice in the classroom (Do), (3) conducting evaluation and reflection on the teaching performance (Evaluation and Reflection), and (4) developing a follow-up plan (RTL) for improving the subsequent lessons. These structured steps ensure that students not only gain practical teaching experience but also continuously engage in a process of professional reflection and improvement through the LS framework.

Based on the observations of Lesson Study implementation within the PPL PPG program across five LPTKs in Indonesia, several key findings were identified at each stage (Plan, Do, See/Reflect):

Collaboration among lecturers, mentor teachers, and pre-service teachers was evident in nearly all LPTKs, although the intensity and quality of collaboration varied. Learning objectives were generally clear, aligned with the curriculum, and realistic, though in some cases the objectives remained too general and insufficiently measurable. The lesson plans (RPP) prepared mostly reflected the integration of TPACK, particularly in the use of digital learning technologies. Instructional strategies were selected through collaborative discussion, though in some institutions the lecturers' role appeared more dominant than that of the pre-service teachers. Learning media and technologies were well-prepared; however, limitations in infrastructure at several partner schools continued to pose challenges.

Pre-service teachers were able to carry out lessons according to the agreed-upon lesson plans, though some still struggled with managing large classes. The use of learning media and technology proved fairly effective, such as interactive PowerPoint slides, online quiz applications, and instructional videos. Students were generally active and participative, particularly when technology-based approaches and group discussions were employed. Mentor teachers and lecturers provided support and reinforcement without overly intervening in the teaching process. Overall, classroom situations were conducive, though student participation varied across schools.

Reflection discussions were conducted after the teaching sessions, involving lecturers, mentor teachers, and pre-service teachers. Feedback was generally constructive and evidence-based, although in some instances it remained rather normative. The analysis of the teaching process included strengths—such as mastery of subject matter and effective use of technology—as well as weaknesses, including time management and limited variation in strategies. Concrete recommendations for improvement were formulated, including diversifying teaching methods, optimizing time allocation, and developing more interactive learning media for the next LS cycle.

The implementation of Lesson Study (LS) within the PPL PPG program across five LPTKs in Indonesia demonstrates its effectiveness as a professional learning model for pre-service teachers. The integration of LS into guided teaching practice allowed students to experience collaborative lesson planning, authentic classroom teaching, and reflective discussions that directly contributed to the development of their pedagogical competence. The findings highlight that pre-service teachers successfully integrated TPACK into their lessons and fostered active student engagement through the use of technology, though challenges in classroom management and the depth of reflection remain.

Overall, LS has proven to be a valuable framework for enhancing the quality of PPL by fostering collaboration among lecturers, mentor teachers, and pre-service teachers, and by embedding a cycle of continuous improvement into the teaching practice. While further institutional support is needed to strengthen infrastructure, promote teacher autonomy, and deepen reflective practices, the evidence suggests that LS provides a sustainable approach to preparing competent, reflective, and adaptive future teachers in Indonesia.

Based on the interviews conducted with pre-service teachers and mentor teachers, several key factors were identified as influencing the implementation of Lesson Study (LS) within the PPL PPG program. These factors can be categorized into supporting factors that facilitated the process and challenging factors that constrained its effectiveness.

Collaborative Engagement

Both pre-service teachers and mentor teachers emphasized the importance of collaboration as a central factor in LS implementation. Successful cycles occurred when all parties—lecturers, mentor teachers, and students—actively contributed during the planning and reflection stages. Mentor teachers highlighted that open communication and willingness to share classroom experiences fostered a productive learning community. However, some pre-service teachers reported that collaboration was sometimes unbalanced, with lecturers or mentor teachers dominating the decision-making process. The following is the supporting data.

Pre-service Teacher (Student A, LPTK 3):

"During the planning stage, I felt really supported because my mentor teacher and the lecturer discussed the lesson plan with me in detail. We shared ideas about the learning

objectives and methods, so I didn't feel like I was working alone. It gave me more confidence to teach."

Mentor Teacher (Teacher B, Partner School):

"Collaboration is very important in Lesson Study. When we sit together with the lecturer and the student teacher, we can combine theory with practical experience. Sometimes the student brings fresh ideas, and we, as teachers, can adapt them to the classroom context. That way, everyone learns from each other."

Pre-service Teacher (Student C, LPTK 1):

"Honestly, sometimes the discussion was dominated by the lecturer. I wanted to share my ideas, but I felt a bit hesitant. Still, I learned a lot by observing how my lecturer and mentor teacher considered different strategies for teaching."

Mentor Teacher (Teacher D, Partner School):

"The challenge is making sure that the student teacher has enough space to express their ideas. If the lecturer talks too much, the student just follows instructions without critical thinking. We try to encourage them to contribute actively during the planning and reflection."

Integration of TPACK and Pedagogical Innovation

Pre-service teachers acknowledged that LS encouraged them to integrate technology, pedagogy, and content knowledge in meaningful ways. The use of digital tools, such as interactive media and online platforms, was seen as a motivating factor that enhanced student engagement. Mentor teachers confirmed that the LS framework provided a structured opportunity for students to experiment with innovative teaching approaches. Nevertheless, limited access to technological infrastructure in some schools posed significant challenges. The following is the supporting data:

Pre-service Teacher (Student E, LPTK 2):

"Lesson Study encouraged me to try using digital tools in my lesson. For example, I designed an online quiz using Kahoot, and the students were very excited to participate. It made the class more interactive compared to just using the textbook."

Mentor Teacher (Teacher F, Partner School):

"I could see that the pre-service teacher was more confident when using technology. The students responded positively because it was something new for them. However, we also faced challenges, like the internet connection being unstable at times, which disrupted the activity."

Pre-service Teacher (Student G, LPTK 4):

"When planning with my mentor teacher and lecturer, I learned how to balance content, pedagogy, and technology. Initially, I only focused on the technology, but then I realized that the teaching method and the way I explained the concept were equally important. This helped me see TPACK in practice."

Mentor Teacher (Teacher H, Partner School):

"Some schools still lack facilities such as projectors or stable Wi-Fi, so not all innovative ideas can be implemented smoothly. But even in those cases, Lesson Study helps the student teachers to think creatively, for instance by preparing offline interactive media or simple visual aids."

Mentoring and Professional Guidance

Intensive guidance from mentor teachers and lecturers was considered crucial for building confidence among pre-service teachers. Interviews revealed that constructive feedback, modeling of effective strategies, and emotional support provided during the LS cycles significantly influenced the quality of teaching practice. At the same time, some mentor teachers noted the difficulty of balancing supportive mentoring with allowing students autonomy, which occasionally hindered the development of independent decision-making skills.

Pre-service Teacher (Student I, LPTK 5):

"At first, I was very nervous about teaching in front of the class. But my mentor teacher always reminded me that mistakes are part of the learning process. After each lesson, she gave me feedback on what went well and what I should improve, which really helped me to grow."

Mentor Teacher (Teacher J, Partner School):

"We try to guide the pre-service teachers step by step. During Lesson Study, I often provide examples of how to manage classroom discussions or handle difficult students. But I also let them try their own strategies, because they need to build confidence through practice."

Pre-service Teacher (Student K, LPTK 1):

"The feedback sessions were very useful. My lecturer and mentor teacher gave specific comments, not just general ones. For example, they pointed out how I could adjust my pacing when explaining concepts. This made me feel supported and motivated to do better in the next cycle."

Mentor Teacher (Teacher L, Partner School):

"One challenge is finding the balance between guiding and giving freedom. Sometimes student teachers want clear instructions, but if we give them everything, they don't learn to make decisions. That's why we try to provide scaffolding and gradually reduce support as they gain confidence."

Reflective Practice

Both groups emphasized the value of reflection as a transformative element of LS. Pre-service teachers described reflection sessions as opportunities to critically analyze their strengths and weaknesses, while mentor teachers considered them essential for cultivating professional habits of continuous improvement. However, it was noted that the depth of reflection varied; some sessions were rich and evidence-based, while others tended to remain descriptive and surface-level.

Pre-service Teacher (Student M, LPTK 2):

"The reflection sessions were the most valuable part for me. After teaching, I could listen to my mentor teacher and lecturer's observations, and they helped me see things I didn't notice during the lesson, like how some students were left behind when I moved too quickly."

Mentor Teacher (Teacher N, Partner School):

"Reflection is where real learning happens. During Lesson Study, we don't only point out mistakes, but we focus on why something worked or didn't work. This helps the student teachers understand their teaching more deeply and prepare better for the next cycle."

Pre-service Teacher (Student O, LPTK 4):

"Sometimes I felt the reflection was too general, like just saying 'you need to improve classroom management'. But when the feedback was more detailed, for example suggesting specific strategies, I could apply it immediately in the next lesson."

Mentor Teacher (Teacher P, Partner School):

"Not all reflections are equally deep. Some student teachers just describe what they did, instead of analyzing it critically. That's why we try to guide them to use evidence, like student responses or their own teaching notes, to support their reflection

Institutional and Contextual Support

Mentor teachers highlighted that institutional support, such as scheduling flexibility, administrative approval, and provision of resources, played a significant role in determining the success of LS implementation. Pre-service teachers echoed these concerns, reporting that heavy administrative demands and limited time often constrained their ability to engage fully in the LS cycles. Furthermore, school contexts—such as class size, student characteristics, and available facilities—were identified as external factors influencing the effectiveness of LS.

Pre-service Teacher (Student Q, LPTK 3):

"Sometimes I felt limited because the school didn't have enough facilities. For example, I planned to use a projector for my lesson, but it wasn't available. I had to quickly adjust by using handouts instead. It was stressful but also taught me to be flexible."

Mentor Teacher (Teacher R, Partner School):

"We support the student teachers as much as possible, but there are times when administrative duties or tight schedules make it hard to fully accommodate Lesson Study activities. For example, if there is an exam week, reflection sessions often get shortened."

Pre-service Teacher (Student S, LPTK 5):

"I think time management was one of the biggest challenges. We only had a few weeks in the school, and fitting in three Lesson Study cycles was very demanding. Sometimes I felt the process was rushed, even though the reflection was very useful."

Mentor Teacher (Teacher T, Partner School):

"Institutional support really matters. When the school leadership understands the value of Lesson Study, they allow us to adjust the timetable and provide resources. But if the leadership is less supportive, it becomes difficult for us and the student teachers to implement LS effectively."

Based on classroom observations and document analysis of teaching artifacts (lesson plans, teaching reflections, and instructional materials), several key impacts of Lesson Study (LS) on pre-service teachers' TPACK (Technological Pedagogical Content Knowledge) development were identified.

The findings indicate a significant improvement in both lesson planning and instructional implementation through the integration of TPACK across the Lesson Study cycles. Document analysis revealed that during the first cycle, lesson plans demonstrated limited technology integration, primarily confined to the use of basic presentation slides. However, in the second and third cycles, pre-service teachers exhibited a more advanced and coherent integration of content, pedagogy, and technology. Lesson plans no longer merely listed digital tools but incorporated interactive media, online quizzes, and context-based instructional strategies aligned with the learning objectives. These revisions were largely influenced by collaborative discussions during Lesson Study reflection sessions.

Classroom observations further demonstrated growth in instructional practice. Pre-service teachers increasingly utilized technology not merely as a supplementary aid but as an integral component of their pedagogical strategies. For example, multimedia resources were used to explain abstract concepts, online polling applications were employed to assess student understanding, and contextual videos were integrated to connect classroom content with real-world situations. Compared to earlier lessons, subsequent cycles showed stronger alignment between technology use, pedagogical approaches, and content delivery, reflecting enhanced technological-pedagogical coherence.

In addition, there was noticeable development in pedagogical responsiveness. Through iterative Lesson Study cycles, pre-service teachers demonstrated an improved ability to adapt instructional strategies based on students' needs. While early lessons tended to follow rigid plans, later cycles showed greater flexibility, such as adjusting technology use or modifying group activities when students appeared

disengaged. Written reflections also revealed increased awareness of the importance of responsiveness, which pre-service teachers attributed to feedback and collaborative analysis during Lesson Study sessions.

Analysis of teaching reflections further indicated a shift from descriptive accounts to more analytical discussions related to TPACK dimensions. Initially, reflections focused primarily on technical aspects, such as whether the technology functioned properly. In later cycles, however, reflections critically examined how technology supported pedagogical strategies and content understanding. This progression suggests that Lesson Study played a significant role in cultivating deeper and more purposeful reflective practices.

Finally, documentation from collaborative planning and reflection meetings highlighted the role of Lesson Study in fostering collective professional knowledge construction. Mentor teachers and peers frequently provided suggestions on how technology could be effectively integrated with content-specific pedagogy, which were subsequently incorporated into revised lesson plans. This collaborative dialogue enriched pre-service teachers' perspectives and accelerated their ability to apply TPACK meaningfully in authentic classroom contexts.

Discussion

The findings of this study reveal that the implementation of Lesson Study (LS) within the PPL program provides a structured and collaborative framework that strengthens pre-service teachers' professional learning. The integration of LS into guided teaching cycles ensured that student teachers engaged in a process of planning, teaching, reflection, and follow-up, which allowed them to experience teaching as an iterative and developmental practice rather than as isolated events (Dimara, 2023; Soleh & Arifin, 2021). This structure resonates with prior research that positions LS as a sustainable professional development model promoting both individual growth and collective knowledge building (Darsih et al., 2023; Maulana & Pradikto, 2025).

Several key factors emerged as critical to the success of LS implementation. Collaborative engagement between lecturers, mentor teachers, and pre-service teachers was central, ensuring that lesson planning and reflection were shared responsibilities rather than individual tasks. Effective mentoring also played a decisive role, as constructive guidance, scaffolding, and encouragement provided by mentor teachers and lecturers helped pre-service teachers build confidence while gradually fostering autonomy (Kristiantari, 2021; Rochmawati & Fatmawati, 2025). Furthermore, reflective practice was a cornerstone of the LS process, as the iterative cycles prompted pre-service teachers to analyze their teaching, identify areas for improvement, and integrate feedback into subsequent lessons (Aykan & Yildirim, 2022; Baumfield et al., 2022). However, challenges such as institutional constraints, resource limitations, and the uneven depth of reflection highlight the importance of systemic support and structured protocols to optimize LS implementation.

The impact of LS on pre-service teachers' TPACK development was particularly evident through both classroom observations and teaching artifacts. LS provided a practical context where pre-service teachers could explore the integration of technology, pedagogy, and content in meaningful ways. Lesson plans evolved from simplistic uses of technology to more integrated approaches that aligned digital tools with pedagogical strategies and content delivery (Børte & Lillejord, 2024; Nicolaou et al., 2022). In classroom practice, pre-service teachers demonstrated increasing pedagogical responsiveness, using technology not merely as a supplement but as a tool to facilitate conceptual understanding and student engagement. Reflection sessions further deepened their awareness of how technology could enhance pedagogy and content delivery, moving from descriptive accounts toward more analytical and evidence-based reasoning. These outcomes confirm that LS serves as an effective vehicle for advancing TPACK competencies, as it provides repeated opportunities for experimentation, feedback, and professional dialogue (Dinçer, 2024; Suryana et al., 2021).

Taken together, the implementation of LS in PPL supports the development of reflective, adaptive, and technology-integrated teaching practices among pre-service teachers. By situating teaching practice within a collaborative and iterative cycle, LS not only enhances the quality of field experiences but also contributes to the broader goal of preparing teachers who are capable of navigating the complex demands of 21st-century classrooms (Inganah et al., 2023; Martinez, 2022). The findings of this study both reinforce and extend previous research highlighting Lesson Study as an effective model of professional development for enhancing teachers' pedagogical competence and reflective practice. Consistent with earlier studies, the collaborative cycles of planning, implementation, and reflection were shown to foster sustainable professional learning grounded in shared inquiry and community-based knowledge construction (Erbilgin & Robinson, 2025; Subasman, 2024). Furthermore, the observed improvement in TPACK integration supports prior evidence indicating that Lesson Study provides a meaningful context for

pre-service teachers to develop the ability to integrate technology, pedagogy, and content in a coherent manner (Huda et al., 2021; Mulyana et al., 2023). However, this study advances the existing literature by demonstrating how embedding Lesson Study within the formal structure of the PPL and PPG programs enables a more systematic and sustained strengthening of TPACK through mentoring, iterative refinement, and structured reflective dialogue. In this way, the study not only confirms the effectiveness of Lesson Study reported in earlier research but also contributes contextualized empirical evidence regarding its implementation in Indonesian teacher education.

The integration of Lesson Study (LS) within the PPL program has important implications for teacher education. For the PPG program, LS ensures that teaching practice becomes a structured process of collaborative planning, reflection, and iterative improvement. For LPTKs, the findings highlight the need to strengthen the capacity of lecturers and mentor teachers to guide reflective practice and support the integration of TPACK through access to technology and training. For partner schools, institutional support in terms of resources, time allocation, and leadership commitment is crucial to sustain LS activities. Strengthening collaboration among PPG programs, LPTKs, and schools will enable LS to function as a transformative model for preparing reflective, adaptive, and technologically competent teachers.

This study has several limitations that should be acknowledged. First, the research was conducted within a specific institutional context and involved a limited number of pre-service teachers enrolled in a particular PPG program, which may restrict the generalizability of the findings to other institutions or regions. Second, the study relied primarily on qualitative data derived from interviews, observations, and document analysis, which, although rich and in-depth, may be subject to researcher interpretation and potential bias. Third, the duration of the Lesson Study implementation was confined to the PPL period, limiting the ability to examine the long-term sustainability of TPACK development and reflective practices beyond the immediate cycles. Additionally, variations in mentoring quality, institutional support, and technological infrastructure were not examined in a comparative manner, which may have influenced the outcomes. Therefore, future research involving larger samples, mixed-method designs, and longitudinal approaches is recommended to provide a more comprehensive understanding of the sustained impact of Lesson Study on TPACK development in teacher education programs.

4. CONCLUSION

The integration of Lesson Study (LS) within the PPL program has been shown to effectively enhance pre-service teachers' professional growth. LS promoted collaboration among lecturers, mentor teachers, and student teachers, as well as structured reflection and continuous improvement. The findings also confirmed that LS positively contributed to the development of pre-service teachers' TPACK competencies through iterative cycles of planning, teaching, and reflection. Despite these benefits, challenges related to limited time and resources persist. Therefore, future research is recommended to examine the long-term impact of Lesson Study on teachers' professional practice and to explore its application across different contexts and subject areas. To strengthen implementation, institutions should provide adequate support, professional development, and technological resources, as well as reinforce collaboration between LPTKs and partner schools. Through these efforts, Lesson Study can serve as a sustainable framework for preparing reflective and adaptive teachers for 21st-century classrooms.

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