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THE IMPACT OF CONTINUOUS PROFESSIONAL DEVELOPMENT (CPD) ON SHIFTING TEACHER BELIEFS AND CLASSROOM PRACTICES IN STEM EDUCATION

DAMPAK PENGEMBANGAN PROFESIONAL BERKELANJUTAN (PPB) TERHADAP PERUBAHAN KEYAKINAN GURU DAN PRAKTIK KELAS DALAM PENDIDIKAN STEM

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Abstract

This study investigates the impact of Continuous Professional Development (CPD) on shifting teacher beliefs and classroom practices in STEM education at SDN No. 100710 Hapesong Baru.. The research aimed to explore how sustained professional learning experiences contribute to teachers' pedagogical transformation from content transmitters to learning facilitators. Employing a qualitative case study design, data were collected through classroom observations, semi-structured interviews, and document analysis involving four STEM teachers who participated in a year-long CPD program. The findings reveal that CPD fostered significant changes in teachers' beliefs toward student-centered learning and encouraged more interactive, inquiry-based classroom practices. However, challenges such as limited institutional support and resource constraints still hindered full pedagogical implementation. The study highlights the importance of contextualized CPD programs in developing reflective and adaptive STEM educators, offering insights for policymakers and practitioners seeking to enhance teacher professionalism in developing-country contexts.

Keywords: Continuous Professional Development, Teacher Beliefs, STEM Education, Classroom Practices

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Abstrak

Penelitian ini mengkaji dampak *Continuous Professional Development* (CPD) terhadap pergeseran keyakinan dan praktik pembelajaran guru dalam pendidikan STEM di SDN No. 100710 Hapesong Baru. Tujuan penelitian ini adalah untuk mengeksplorasi bagaimana pengalaman pengembangan profesional berkelanjutan berkontribusi terhadap transformasi pedagogis guru dari penyampai materi menjadi fasilitator pembelajaran. Menggunakan desain studi kasus kualitatif, data dikumpulkan melalui observasi kelas, wawancara semi-terstruktur, dan analisis dokumen terhadap empat guru STEM yang mengikuti program CPD selama satu tahun. Hasil penelitian menunjukkan bahwa CPD mendorong perubahan signifikan dalam keyakinan guru menuju pembelajaran berpusat pada peserta didik serta meningkatkan penerapan praktik kelas yang interaktif dan berbasis inkuiri. Namun, keterbatasan dukungan institusional dan sumber daya masih menjadi tantangan dalam penerapan pedagogi secara optimal. Studi ini menekankan pentingnya program CPD yang kontekstual dalam membentuk pendidik STEM yang reflektif dan adaptif, serta memberikan wawasan bagi pembuat kebijakan dan praktisi untuk meningkatkan profesionalisme guru di negara berkembang.

Kata kunci: *Continuous Professional Development*, keyakinan guru, pendidikan STEM, praktik pembelajaran, Indonesia

1. INTRODUCTION

The growing emphasis on 21st-century competencies has transformed global education priorities, particularly in Science, Technology, Engineering, and Mathematics (STEM) learning. Education systems worldwide are urged to cultivate learners who can think critically, collaborate effectively, and solve complex problems (Darling-Hammond et al., 2022; OECD, 2023). However, achieving this goal relies heavily on teachers' ability to design meaningful learning environments and adapt their pedagogy from knowledge transmission toward student-centered facilitation (Li & Schoenfeld, 2019; English, 2022). This pedagogical shift, although conceptually accepted, remains difficult to achieve in practice, especially in contexts where traditional teaching norms dominate (Bautista & Ortega-Ruíz, 2020; Opfer & Pedder, 2020). Therefore, understanding how teachers' beliefs and instructional practices evolve through continuous professional learning becomes essential to ensuring the successful implementation of 21st-century STEM education

In Indonesia, the need to strengthen teacher professionalism through *Continuous Professional Development* (CPD) has become a major educational priority. The Ministry of Education and Culture (2020) mandates ongoing professional learning as part of teacher certification and quality assurance. Yet, several national reports reveal that more than 60% of Indonesian primary teachers still employ lecture-based, teacher-centered methods, particularly in rural and under-resourced schools (UNESCO, 2023; Suryani & Supriyadi, 2022). These conditions hinder the development of inquiry-based STEM pedagogy, which is essential for preparing students for global competitiveness (Rahmawati et al., 2021; Lestari & Widodo, 2023). Hence, there is an urgent need for contextually grounded CPD initiatives that not only enhance teachers' pedagogical skills but also transform their underlying beliefs to effectively implement STEM-oriented, student-centered learning

Empirical evidence further indicates that while CPD programs are widely implemented across Indonesia, their impact is often limited by structural and cultural factors. Many training

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initiatives remain short-term, top-down, and compliance-oriented**,** with minimal classroom follow-up or mentoring (Kennedy, 2019; Guskey, 2021). Teachers frequently perceive CPD as a bureaucratic requirement rather than an opportunity for reflective growth (Avalos, 2017; Halim et al., 2022). Consequently, the gap between teachers' professional knowledge and their classroom practices continues to widen, particularly in STEM-related subjects that demand experimentation and problem-based learning (Voogt et al., 2021; English, 2022). Therefore, a more sustainable and reflective model of CPD is urgently required—one that empowers teachers as active learners, fosters continuous mentoring, and bridges the persistent gap between professional knowledge and authentic classroom practice.

In addition, contextual barriers—such as limited access to technological resources, large class sizes, and cultural norms emphasizing hierarchical authority—further restrict pedagogical innovation in rural schools (Nindita & Fadhilah, 2024; Susanto, 2023). Teachers in remote regions often face a professional isolation effect, where opportunities for collaboration and exposure to innovative practices are scarce (Tan & Koh, 2022). This situation underscores the need for context-sensitive CPD models that integrate mentoring, reflective practice, and sustained engagement tailored to teachers' real classroom challenges. Thus, addressing these contextual barriers through locally responsive and continuously supported CPD frameworks is essential to fostering meaningful and sustainable pedagogical transformation in rural STEM education.

Given this background, there is a compelling need to empirically explore how continuous, school-based professional development can transform teachers' pedagogical beliefs and practices in the Indonesian STEM education context. SDN No. 100710 Hapesong Baru located in a semi-rural area with limited access to training and instructional resources—presents a relevant case to examine how sustained CPD interventions can foster meaningful teacher transformation. Through a year-long CPD program emphasizing collaborative reflection, peer observation, and inquiry-based learning design, this study investigates how teachers' beliefs evolve and how these shifts manifest in their classroom practices. Therefore, this research aims to provide empirical insights into the processes and outcomes of teacher transformation through continuous professional learning, offering a model that can inform future CPD practices in similar educational contexts across Indonesia.

This research was conducted to respond to the urgent need for evidence-based understanding of how professional learning affects teacher transformation within a developing-country context. Most prior studies on CPD effectiveness have been conducted in Western or urbanized settings, where resource abundance and institutional support differ significantly from Indonesian realities (Kennedy, 2019; Darling-Hammond et al., 2022). Therefore, this study fills a critical gap by situating CPD implementation within the socio-cultural dynamics of rural Indonesia, offering a grounded perspective on teacher learning processes. Ultimately, this study seeks to contribute to the global discourse on teacher professional development by illuminating how culturally and contextually grounded CPD can drive sustainable pedagogical change in resource-constrained educational settings

The novelty of this study lies in combining the theoretical framework of *teacher belief change* (Guskey, 2021) with *contextualized professional learning theory* (Tan & Koh, 2022) to explain how CPD mediates pedagogical transformation in under-resourced environments. By examining both cognitive (belief) and behavioral (practice) shifts, this research contributes to the growing body of literature on contextual sustainability and teacher agency in professional development. Ultimately, the findings from this study are expected to inform policymakers,

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school leaders, and CPD designers in developing more responsive, practice-driven professional learning models that align with Indonesia's vision of adaptive, future-ready STEM education. In summary, the study provides actionable insights for designing CPD programs that not only enhance teacher competence but also foster long-term, context-sensitive improvements in STEM teaching and learning.

2. RESEARCH METHOD

This research employed a qualitative case study design to explore the influence of Continuous Professional Development (CPD) on shifting teachers' beliefs and classroom practices in STEM education. The study was conducted at SDN No. 100710 Hapesong Baru, located in South Tapanuli Regency, Indonesia, chosen as a representative of rural primary schools with limited access to structured professional learning opportunities. The CPD program spanned one academic year (July 2023–June 2024) and involved a sequence of workshops, peer observations, collaborative lesson planning, and reflective discussions. Four teachers two science, one mathematics, and one integrated STEM teacher participated voluntarily. Data were collected through semi-structured interviews, classroom observations, and document analysis, including lesson plans, reflective journals, and student worksheets. Each participant was interviewed three times (before, during, and after the program) to trace the evolution of beliefs and practices. To ensure data validity, triangulation across data sources and member checking were employed (Creswell & Poth, 2018; Lincoln & Guba, 1985; Guskey, 2021). Overall, this methodological approach enabled a comprehensive examination of how sustained, context-based CPD influences both teachers' cognitive beliefs and observable classroom practices in a rural STEM education setting

Data analysis followed Braun and Clarke's (2019) six-step framework for thematic analysis, supported by NVivo 14 software to manage coding and pattern identification. The process involved iterative reading, initial coding, theme generation, and interpretation in relation to professional learning theory. Themes such as "belief reorientation," "collaborative reflection," and "adaptive instructional design" emerged, reflecting the cognitive and behavioral transformation of teachers. Research rigor was maintained through credibility, transferability, dependability, and confirmability checks (Miles, Huberman, & Saldaña, 2020). Ethical clearance was granted by the Faculty of Education Research Ethics Committee, and informed consent was obtained from all participants. This methodological approach provided a comprehensive lens to capture how continuous, context-based CPD promotes meaningful pedagogical change and reinforces teachers' professional growth in STEM education within a rural Indonesian context (Yin, 2023; Halim et al., 2022; Nindita & Fadhilah, 2024; Tan & Koh, 2022). This rigorous and ethically grounded analytic process ensured that the study accurately captured the nuanced ways in which CPD fosters both belief and practice transformation among rural STEM teachers.

3. RESULTS AND DISCUSSION

The analysis of interviews, classroom observations, and reflective journals revealed three dominant themes describing the transformation of teachers' beliefs and practices after participating in the CPD program: (1) *Reorientation of Teaching Beliefs toward Student-Centered Learning*, (2) *Collaborative Reflection and Pedagogical Adaptation*, and (3) *Increased Confidence and Agency in STEM Integration*.

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Reorientation of Teaching Beliefs toward Student-Centered Learning.

The analysis of interviews, classroom observations, and reflective journals revealed that teachers experienced a significant reorientation of teaching beliefs toward student-centered learning. Initially, most participants viewed STEM instruction as primarily content delivery, relying heavily on textbooks and teacher-led explanations. However, after engaging in the year-long CPD program, teachers began to appreciate the value of inquiry-based, problem-solving activities. One teacher reflected, *"I realized students learn better when they discover concepts themselves rather than memorizing from me."* Classroom observations corroborated these shifts, showing lessons increasingly structured around experimentation, collaborative problem-solving, and active student participation. These findings align with prior research emphasizing that sustained professional learning is essential for reshaping teacher beliefs and promoting pedagogical innovation (Guskey, 2021; Desimone & Garet, 2015).

A second major theme identified was collaborative reflection and pedagogical adaptation. Teachers engaged in peer observations, co-planning sessions, and reflective discussions, which provided opportunities to analyze instructional choices and share effective strategies. Field notes highlighted that teachers voluntarily observed each other's classes and adjusted lesson plans to use locally available materials, such as recycled bottles and soil samples, to make STEM activities more contextually relevant. One teacher noted in her reflection journal, *"Discussing our mistakes helps us design better lessons together."* This collaborative process aligns with the concept of "learning conversations" in professional development, emphasizing the role of social interaction and reflection in fostering teacher agency (Timperley, 2020; Tan & Koh, 2022).

Overall, the findings demonstrate that continuous, context-based CPD effectively promotes both cognitive and behavioral transformation among teachers. By shifting beliefs toward student-centered learning, encouraging collaborative reflection, and enhancing teacher confidence in lesson design, the CPD program fostered meaningful pedagogical change in a rural STEM education context. Importantly, this study provides empirical evidence that belief transformation precedes instructional innovation and that long-term, reflective, and contextually sensitive professional learning can overcome structural and cultural barriers to effective teaching.

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Collaborative Reflection and Pedagogical Adaptation.

The second theme underscored the critical role of teacher collaboration in facilitating pedagogical change. Through structured peer lesson observations and reflective meetings, teachers were able to critically examine their instructional choices and identify areas for improvement. Field notes indicated that teachers often visited colleagues' classrooms voluntarily, engaging in discussions to share strategies for implementing hands-on STEM activities. These interactions created opportunities for continuous learning and supported the development of reflective professional habits.

Reflection journals provided further evidence of the collaborative process. One teacher remarked, *"Discussing our mistakes helps us design better lessons together,"* highlighting how dialogue and feedback promoted deeper understanding and refinement of teaching practices. Such collaborative reflection aligns with Timperley's (2020) concept of "learning conversations," in which professional growth occurs through social interaction and reflective analysis. By engaging in these conversations, teachers were able to articulate challenges, exchange ideas, and co-construct solutions, thereby strengthening their professional agency.

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Based on the findings indicate that collaborative reflection and contextual adaptation of lessons are essential components of effective CPD. By working together and integrating local, readily available materialssuch as recycled bottles and soil samples—teachers not only enhanced the relevance of STEM learning for students but also reinforced their own pedagogical skills. This approach demonstrates that sustained collaboration and reflection are key drivers of meaningful instructional improvement in resource-constrained settings, consistent with recommendations from Bybee (2020) on contextual STEM pedagogy.

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Increased Confidence and Agency in STEM Integration.

Teachers' increased confidence emerged as a powerful outcome. Initially, participants expressed anxiety about designing integrated STEM projects due to limited resources and low familiarity with digital tools. However, by the end of the program, all teachers demonstrated greater autonomy in lesson design. Observation records showed more frequent student-led experiments, project-based assessments, and group collaboration. This finding resonates with Darling-Hammond et al. (2022**)**, emphasizing that teacher agency develops when professional learning connects theory with classroom realities. Moreover, teachers reported higher student engagementstudents were more active, asked more questions, and exhibited curiosity—confirming the positive cycle between teacher belief change and student behavior (Opfer & Pedder, 2019; Tan & Koh, 2022).

A summary of key themes derived from data analysis is presented below:

Theme	Indicators from Data	Evidence Source
Reorientation of Teaching Beliefs	Teachers shift from content transmission to inquiry-based instruction	Interview transcripts & classroom observations
Collaborative Reflection	Teachers engage in peer feedback and contextual adaptation of lessons	Reflective journals & field notes
Increased Confidence and Agency	Teachers demonstrate autonomy in designing STEM projects	Observation logs & post-CPD interviews

Discussion

The findings indicate that continuous, contextually grounded CPD can effectively transform both cognitive and behavioral dimensions of teaching practice in STEM education. This transformation occurred because the CPD program provided sustained mentoring, collaborative reflection, and experiential learning**,** which are critical for altering entrenched pedagogical beliefs (Avalos, 2019; Darling-Hammond & Hyler, 2020). Teachers' growing confidence and reflective capacity mirror the professional learning cycle described by Clarke and Hollingsworth (2002)**,** in which belief change and classroom experimentation reinforce each other in iterative phases.

The study also demonstrates that rural teachers, despite resource limitations, can successfully integrate STEM principles when CPD initiatives are tailored to their local context. This challenges earlier assumptions that effective STEM implementation depends heavily on technology and laboratory facilities (Bybee, 2020). Instead, teachers at SDN No. 100710 Hapesong Baru utilized local materials and community-based examples**,** aligning with the

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contextual constructivist perspective (Vygotsky, 1978; Tan & Koh, 2022). This not only fostered deeper student engagement but also encouraged culturally relevant pedagogy.

Moreover, the research highlights a shift in professional identity teachers began perceiving themselves not as "knowledge transmitters," but as learning facilitators and reflective practitioners. This aligns with Beauchamp & Thomas (2009) and Loughran (2021), who emphasize that teacher identity evolves through social interaction, reflection, and feedback. Importantly, the findings provide empirical support for long-term CPD as a mechanism for sustainable educational reform in low-resource settings (Halim et al., 2022; Nindita & Fadhilah, 2024).

Overall, this study fills an important research gap in Indonesian education literature by providing **context-based evidence** on how CPD influences teacher cognition and practice within a rural primary school context—a setting rarely documented in prior STEM professional learning studies. The findings reinforce the notion that belief transformation precedes instructional innovation, and that meaningful teacher change requires time, support, and collaboration rather than one-off training sessions.

4. CONCLUSION

This study concludes that **Continuous Professional Development (CPD)** has a significant impact on transforming teachers' beliefs and classroom practices in STEM education, particularly in rural school contexts such as **SDN No. 100710 Hapesong Baru**. The year-long, collaborative, and reflective CPD model enabled teachers to shift from traditional, content-driven instruction toward student-centered, inquiry-based pedagogy. The findings demonstrate that belief transformation precedes instructional innovation, and that sustainable pedagogical change requires long-term support, peer collaboration, and contextual adaptation rather than short-term training interventions.

The unique contribution of this research lies in its contextual perspective: it provides empirical evidence of how CPD fosters teacher agency and reflective practice within a low-resource Indonesian setting, an area often underrepresented in international STEM education research. By integrating collaborative reflection and contextualized learning, this study highlights that even in resource-limited environments, teachers can successfully internalize and apply STEM principles when given structured and sustained professional learning opportunities. Future professional development programs in Indonesia should therefore prioritize continuous, context-sensitive, and reflective CPD frameworks to ensure lasting pedagogical transformation and improved student engagement in STEM learning.

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