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STEM TEACHER PROFESSIONAL DEVELOPMENT IN RURAL PRIMARY SCHOOLS: A LESSON PLANNING APPROACH USING MODEL OF EDUCATIONAL RECONSTRUCTION

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ABSTRACT

Integrated STEM education requires teachers to move beyond teaching subjects in isolation. However, many rural primary STEM teachers face challenges due to limited access to professional development that is relevant to their teaching context. This qualitative study explores Rural primary STEM teachers' perceptions of effective Teacher Professional Development (TPD) qualities and examines how these qualities were enacted through structured lesson planning informed by the Model of Educational Reconstruction (MER). The study involved 15 rural primary STEM teachers. Data were collected through semi-structured interviews, lesson plan analysis, and classroom observations. The data were analysed thematically to identify key patterns related to teachers' professional development experiences and instructional practices. The findings reveal three TPD qualities that teachers perceive as essential: (1) self-development and curriculum innovation, (2) teamwork and flexibility, and (3) adaptivity. These qualities were enacted through lesson planning processes aligned with MER and the 5E instructional model, allowing teachers to contextualise STEM content, collaborate on instructional decisions, and adapt teaching strategies to meet classroom needs. Overall, these qualities allow teachers to contextualise STEM content, collaborate on instructional decisions, and adapt teaching strategies to classroom needs.

Keywords: *Integrated STEM Education, Teacher Professional Development Qualities, Rural Primary School, Lesson Plan, Practice-Based Professional Learning.*

INTRODUCTION

In today's information-driven and technology-rich society, science, technology, engineering, and mathematics (STEM) education is increasingly recognised as essential for developing students' problem-solving, critical thinking, and real-world application skills (Li et al., 2020; Thibaut et al., 2018). Subjects in schools, particularly at the primary level, are still predominantly taught as separate disciplines across many countries (Honey et al., 2014). This disconnection becomes a persistent challenge for STEM teachers, who are expected to implement integrated STEM approaches without sufficient pedagogical preparation.

Most international studies consistently report that most K–12 teachers receive training within their own disciplinary specialisation, which often limits their ability to implement integrated, interdisciplinary approaches that enact integrated STEM education (Cavlazoglu & Stuessy, 2017; Margot & Kettler, 2019). Teacher professional development (TPD), therefore, plays a critical role in equipping in-service teachers with the pedagogical knowledge, instructional strategies, and reflective capacities needed for STEM integration (Brand, 2020; Darling-Hammond et al.,2017). However, many agree on what makes TPD effective, many programmes still rely on standard workshops that do not fully consider teachers' real

classroom and contextual needs (Lo, 2021). While existing research has widely documented the features of effective TPD, fewer studies have examined how these qualities are enacted through teachers' everyday teaching practices, such as lesson planning, especially in rural school STEM contexts. Therefore, as a result, there is a gap between theoretical understandings of effective TPD and the practical mechanisms through which professional learning is embedded into classroom practices.

To fill up this gap, the study adopts Duit's Model of Educational Reconstruction (MER) as a practice-oriented framework to examine how TPD qualities can be operationalized through structured lesson planning. This study positions lesson planning (Appendix A) as a form of practice-based professional learning, where STEM teachers actively translate professional development qualities into classroom enactment. By integrating MER with the 5E Instructional Model, this study develops a Contextualised TPD Framework that illustrates how professional learning, instructional design, and reflective practice interact within teachers' daily work.

This study focuses on three broad areas: first, it discusses the theoretical foundations of integrated STEM education; second, it identifies key qualities of effective TPD for STEM teachers; and third, it introduces the Contextualised TPD Framework developed from MER, as shown in Figure 1, to explain how these qualities are enacted through lesson planning in rural primary school STEM contexts.

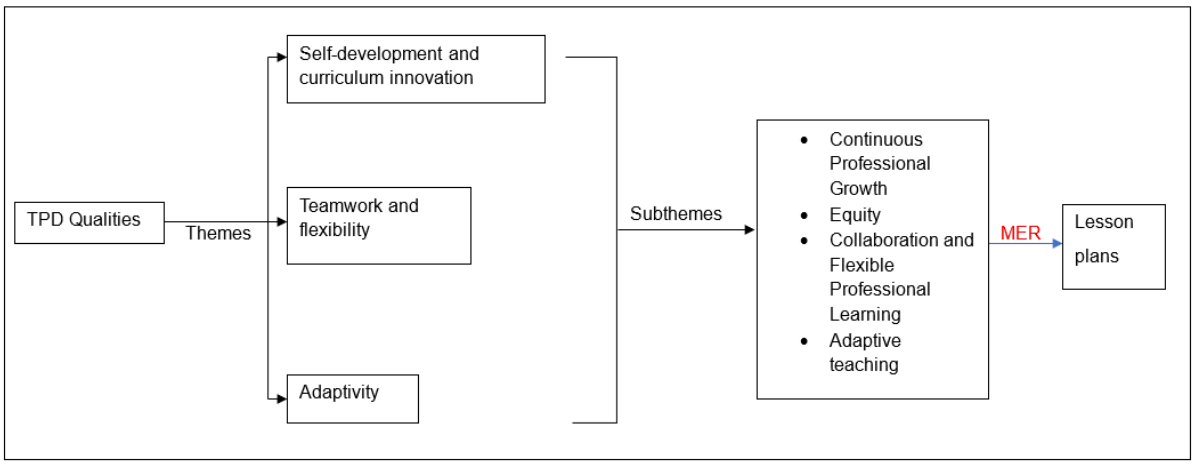

Figure 1. *Contextualised TPD Framework*

Integrated STEM Education

Integrated STEM education refers to instructional approaches that intentionally connect concepts and practices across science, technology, engineering, and mathematics to support meaningful, real-world learning experiences (English, 2016). Rather than treating STEM disciplines as isolated subjects, integrated STEM emphasises interdisciplinary and transdisciplinary learning, where knowledge and skills are applied to authentic problems that reflect real-world contexts (Li et al., 2020; Vasquez et al., 2013). Research suggests that well-designed integrated STEM instruction can enhance student engagement, conceptual understanding, and problem-solving abilities (Margot & Kettler, 2019).

Implementing integrated STEM education presents substantial challenges for teachers. Studies across different educational systems consistently report that many teachers lack sufficient preparation to design interdisciplinary lessons, particularly when they have been trained within single-subject specialisations (Summers et al., 2005). Designing integrated STEM lessons requires teachers to align goals across subjects, choose suitable teaching strategies, and address diverse student needs, which goes beyond traditional subject-based teaching.

These challenges are further amplified in rural school contexts. International research indicates that rural teachers often experience professional isolation, limited access to specialised STEM resources, and fewer opportunities for sustained, context-responsive professional learning (Anning, 2025). As a result,

although integrated STEM is widely promoted in policy, classroom implementation is still inconsistent, especially in rural primary schools, where teachers need professional learning that is both theory-based and practical for daily teaching. Implementing integrated STEM education is not easy in rural areas. In this regard, lesson planning plays an important but often overlooked role in supporting integrated STEM implementation. Through lesson plans, teachers translate interdisciplinary ideas into practical teaching, manage curriculum demands, and reflect on their instructional choices. However, limited STEM research has examined lesson planning as a form of professional learning that strengthens teachers' ability to implement integrated STEM. This study addresses this gap by viewing integrated STEM through a teacher professional development lens and positioning MER-guided lesson planning as a practical approach to developing integrated STEM teaching in rural primary schools.

Teacher Professional Development for STEM

TPD is widely recognised as one of the most important contributors to improving teaching and learning, especially in STEM education, where teachers constantly face new instructional demands (Darling-Hammond et al., 2017). Effective TPD goes beyond improving content and pedagogical knowledge, as it also shapes teachers' beliefs, influences their classroom practices, and ultimately supports strengthening student learning outcomes (Desimone, 2009; Garet et al., 2001). In STEM settings, teachers express the need for structured and well-designed development opportunities that provide concrete, practical strategies for implementing integrated approaches, a pattern frequently highlighted in recent reviews (Ibáñez & Delgado-Kloos, 2018; Martín-Páez et al., 2019).

Margot and Kettler (2019) highlight that teachers view high-quality TPD as essential for integrated STEM teaching, particularly when it focuses on strengthening pedagogical content knowledge, offering relevant curriculum materials, and providing ongoing support rather than one-off workshops. Similarly, scholars have encouraged a shift from "professional development" to "professional learning" to highlight teachers' agency and ownership in directing their growth (Smith, 2017). In rural settings, these needs are even more pronounced, creating a significant gap between teachers' professional needs and the support currently available. Responding to this gap, the present study explores how rural STEM teachers understand TPD qualities and examines how these qualities can be strengthened through structured, collaboratively developed lesson plans.

Qualities of Effective TPD

In general, effective TPD carries several core qualities:

1. Active learning - giving teachers chances to observe models of good practice, try out new strategies, receive feedback, and reflect on what works (Borko, 2004; Desimone, 2009).
2. Focus on student learning - keeps student learning at the centre by encouraging teachers to study their students' work, identify misunderstandings, and adjust their lessons accordingly (Boz, 2023; Loucks-Horsley et al., 2010).
3. Strong subject-specific focus - ensuring that the content of professional learning matches the real demands of STEM subjects (Kennedy, 2016).
4. Collaboration - allowing teachers to learn from one another through meaningful conversations and shared problem-solving (Vescio et al., 2008; Wenger, 1998).
5. Sustained duration and ongoing support - which is particularly important in rural settings where access to resources may be limited (Borko, 2004; Garet et al., 2001).

This study investigates which of these qualities are most suitable for rural primary STEM teachers and how they can be operationalised through lesson plans designed for integrated STEM education.

Research Question

The following research questions guide the study:

- RQ1: What are the teachers' conceptions of effective teacher professional development qualities in STEM education?

- RQ2: How do these views align with current research on effective teacher professional development?
- RQ3: How does the application of lesson plans in this study impact teachers' professional learning in STEM disciplines?

METHODOLOGY

This is a qualitative research design to explore rural primary STEM teachers' perceptions about effective TPD qualities and how these qualities were enacted through structured lesson planning. Qualitative research aims to explore human experiences in greater depth and complexity. (Creswell 2003; Denzin & Lincoln 2011).

Participants and Contexts

The participants comprised 15 STEM teachers (8 Science teachers and 7 Mathematics teachers) from rural primary schools located in a district in Malaysia. Each participant was assigned a code from T1 to T15 to ensure confidentially. All participants were in-service teachers actively involved in STEM teaching.

Data Collection

Data were collected using multiple methods to support triangulation and enhance trustworthiness (Maxwell, 2005). These included:

1. Semi-structured interviews - which explored teachers' conceptions of effective TPD, experiences with STEM teaching, and reflections on lesson plan implementation;
2. Document analysis **-** involving teachers' lesson plans
3. Classroom observations - conducted during lesson implementation and collaborative planning discussions.

Progression of the Study

Interview. All teachers participated in semi-structured interviews, responding to questions such as: *"How would you describe the qualities of an effective STEM teacher in terms of professional development?" "How do you personally define effective TPD in the context of STEM teaching and learning in rural schools?" "How well do current PD initiatives support the development of STEM teachers in rural contexts?" "Do you feel the TPD qualities you mentioned earlier are supported by recent educational practices or research trends?" "How did implementing the lesson plans influence your understanding of STEM teaching and learning?"*, and *"In what ways did the lesson plans help you improve or modify your instructional practices?"* These questions were designed to describe teachers' TPD experiences and their responses to the lesson plan implementation.

Lesson Plan Implementation and Classroom Observations. Additional data collection involved classroom observations and analysis of STEM lesson plans. Teachers were provided with lesson plan samples (Appendix A) that were specifically designed to embed TPD qualities to support integrated STEM teaching. The sample lesson plan provided was a science lesson plan, which could also be adapted for Mathematics by modifying the content accordingly. Each lesson plan was designed for either a 30-minute or one-hour lesson. Teachers were given brief instructions on how to implement the lesson plans in their classrooms. During the implementation process, teachers documented any barriers or challenges encountered.

The lesson plans were developed based on the framework shown in Figure 1, which integrates the three components of Duit's Model of Educational Reconstruction (MER) into a coherent instructional process. MER Component 1 (Analysis of Content Structure) supported the contextualisation of curriculum content, allowing teachers to transform abstract STEM concepts into locally meaningful learning experiences. MER Component 2 (Analysis of Teaching and Learning) informed pedagogical design by encouraging inquiry-based, collaborative, and technology-supported strategies aligned with key TPD qualities. MER Component 3 (Development and Evaluation of Instruction) emphasised lesson

implementation and reflective evaluation, enabling teachers to examine student learning outcomes and refine their instructional practices.

The lesson plans were structured using the 5E instructional approach: Engage, Explore, Explain, Elaborate, and Evaluate. Although originally developed as an instructional model (Bybee et al., 2006), the 5E approach in this study was used as a lesson planning framework aligned with the Contextualised TPD Framework for rural STEM education. It provided a consistent yet flexible structure through which TPD qualities could be embedded across instructional phases. Not all five phases were included in every lesson; instead, the 5E structure was adapted to suit specific lesson objectives and classroom contexts.

Classroom observation data were analysed together with interview and lesson plan data as part of the thematic analysis. The observations were coded using the same analytical framework to examine the alignment between teachers' reported perceptions and their enacted classroom practices. This integration strengthened triangulation by validating teachers' self-reported TPD qualities through observed instructional behaviours. Table 1 shows the summaries of the alignment between the MER components, the 5E instructional model, and the data sources used in this study.

Table 1. *Summaries The Alignment Between the MER Components, the 5E Instructional Model, and the Data Sources Used in This Study*

MER Component	Focus of the Component	Related 5E Phase(s)	Data Sources
Component 1: Analysis of Content Structure	Reconstructing STEM content to ensure conceptual clarity and contextual relevance	Engage, Explore	Interview data; STEM lesson plans
Component 2: Analysis of Teaching and Learning	Examining pedagogical strategies, student engagement, and instructional decisions	Engage, Explore, Explain	Interviews; lesson plans; classroom observations
Component 3: Development and Evaluation of Instruction	Reflecting on lesson implementation and refining instructional practices	Elaborate, Evaluate	Classroom observations; reflective interview responses

Ethical Considerations

During the initial meeting, the teachers were briefed on the purpose and procedures of the study. Participants were provided with an information sheet outlining the purpose of the study, the voluntary nature of participation, and the steps taken to protect confidentiality. Informed consent was obtained from all participants. Ethical approval for this study was granted by the *Bahagian Perancangan dan Penyelidikan Dasar Pendidikan* (BPPDP).

Data Analysis

Data were analysed using Braun and Clarke's (2006) six-phase thematic analysis. The researcher first familiarised themselves with the data through repeated reading of interview transcripts, lesson plans, and observation notes. Initial codes were generated inductively to identify recurring patterns across the data sets. These codes were then reviewed, refined, and organised into broader themes and subthemes related to TPD qualities in STEM education.

To enhance analytical rigour, peer debriefing was conducted with fellow researchers to discuss emerging codes and themes, supporting reflexivity and minimising individual researcher bias. In addition, data from interviews, lesson plans, and classroom observations were compared to identify convergent patterns, thereby strengthening triangulation and credibility.

FINDINGS

Analysis of interview data, lesson plan implementation, and classroom observations identified three key TPD qualities that rural primary STEM teachers perceived as important to their professional practice:

1. Self-development and curriculum innovation
2. Teamwork and flexibility
3. Adaptivity

These themes reflect teachers' understandings of effective professional learning within their specific rural teaching contexts. The findings are presented below, supported by illustrative excerpts from participants that represent shared patterns across the data.

Theme 1: Self-Development and Curriculum Innovation

Teachers consistently emphasised professional development experiences that supported both personal growth and curriculum-related innovation. Participants described effective TPD as learning opportunities that enhanced their confidence level, expanded their pedagogical knowledge, and enabled them to adjust teaching approaches to better support rural student understanding.

For example, T5 shared that professional learning experiences increased confidence level to experiment with new teaching strategies, "*When I attend training, I feel more confident to try new ways in my lesson, especially to help weaker pupils understand."*

Similarly, T9 highlighted the importance of alignment between professional learning and curriculum demands, noting that TPD was most meaningful when it provided ideas that could be applied directly in classroom practice. These offer that these practical strategies could be applied directly in the classroom.

Subtheme: Continuous Professional Growth. They described continuous professional growth as enabling them to modify and adapt curriculum strategies to meet the diverse needs of their students. As T8 explained, *"We individualise our lesson plans for our students,"* demonstrating how TPD equips teachers to tailor lessons according to varying student abilities. This indicates how professional learning informed differentiated instructional planning. In several cases, teachers noted that positive student engagement reinforced their motivation to further refine integrated STEM practices.

In terms of lesson plan implementation, the structured 5E phases, particularly *Explore* and *Elaborate*, provided teachers with trial opportunities and refined curriculum innovations while observing students' responses in real time. MER Model Component 1 (Analysis of Content Structure) was directly operationalised, as teachers translated abstract STEM concepts into contextually relevant learning experiences, effectively linking professional growth with practical classroom application.

Subtheme: Equity. Equity emerged as an important consideration within curriculum innovation, where STEM teachers emphasised the need to design lessons that addressed diverse student abilities and learning needs, particularly in rural classrooms. This commitment was reflected in lesson plans that integrated differentiated activities, especially within the *Explain* and *Evaluate* phases. These practices indicate that teachers viewed equity-oriented instruction as integral to effective STEM teaching within their context.

Theme 2: Teamwork and Flexibility

Collaboration was widely perceived as a key feature of effective TPD. The key factor of teamwork is to share pedagogical strategies with other teachers to improve instructional practices and confidence in the classroom. As T12 explained, "*When we discuss lesson ideas with other teachers, I learn new ways to engage my students and adjust my activities for different levels."* Similarly, T14 described that collaboration has a positive impact on student learning outcomes. These show that professional peer supports enable rural STEM teachers to continuously refine instructional strategies.

Subtheme: Collaboration and Flexible Professional Learning. Teachers reported that collaborative TPD experiences enabled them to learn from peers and experienced STEM educators. For example, T7 noted that experienced teachers played a valuable role in sharing practical strategies, while T3 emphasised that professional development extended beyond technical knowledge to include social interaction and mutual support.

Lesson plans provide structured opportunities for collaborative enactment, particularly during the Engage and Explore phases of the 5E model, allowing teachers to co-plan, observe peer instruction, and share reflections. Through collective planning and reflection, teachers analysed instructional strategies and adapted them to suit their classroom contexts, reflecting MER Component 2 (Analysis of Teaching and Learning).

Teachers highlighted the value of lesson plans, which could be modified to suit varying time constraints and the diverse needs of students, particularly in rural settings. Observational data indicated that teachers frequently adjusted activities during lesson enactment while maintaining alignment with instructional objectives.

Theme 3: Adaptivity

Teachers' focus on developing adaptive teaching practices as a central component of effective TPD. Teachers described adjusting instructional strategies based on ongoing observation and reflection. T6 explained, "*I often change the way I explain concepts after seeing how students respond.*" Similarly, T11 observed, *"Being open to new teaching strategies from training helps me meet students where they are,"* emphasising that TPD encourages teachers to respond proactively to the varying needs and abilities of their students. These suggests that TPD supported responsive and reflective teaching practices.

Subtheme: Adaptive Teaching. Teachers noted that the 5E lesson plans' structured flexibility facilitated adaptive teaching, particularly in the Explore and Elaborate phases. These phases allowed teachers to modify instruction in response to student engagement and understanding. MER Component 3 (Development and Evaluation of Instruction) was evident as teachers reflected on lesson effectiveness and made instructional adjustments accordingly. Across the data, teachers' adaptive teaching practices were grounded in continuous reflection, reflecting their view of adaptability as fundamental to effective STEM teaching in rural contexts.

Summary of Findings

Overall, the findings demonstrate that rural primary STEM teachers conceptualised effective TPD as practice-based, collaborative, and adaptive. Through MER- and 5E-informed lesson planning, teachers enacted self-development, curriculum innovation, teamwork, flexibility, and adaptivity, positioning lesson planning as a key mechanism for embedding professional learning within everyday classroom practice.

Integrating Findings Across Framework

Across all three themes identified in this study, teachers' understandings of effective TPD were closely aligned with the MER model and the 5E instructional model. Apart from functioning as an abstract framework, the MER and 5E instructional model provided analytical lenses for understanding how TPD qualities were enacted through teachers' lesson planning and classroom practices in rural STEM contexts.

Curriculum innovation and self-development were strongly associated with MER Component 1 (Analysis of Content Structure), where rural teachers restructured STEM content to make it more contextually relevant for their students. This alignment was seen in how teachers used the Explore and Elaborate phases of the 5E model to try different teaching strategies and observe students' responses. These practices indicate that curriculum innovation was enacted through creative lesson planning rather than isolated professional development activities. Teamwork and flexibility are closely related to MER

Component 2 (Analysis of Teaching and Learning) as STEM teachers are actively engaged in collaboration, lesson planning, and peer discussion. The Engage and Explore phases of the 5E instructional Model give a shared reference point that enables teachers to adapt pedagogical strategies to suit their classroom contexts. In rural settings, these shared practices appeared to support collective sense-making around integrated STEM teaching.

Adaptivity was correspondingly linked to MER Component 3 (Development and Evaluation of Instruction), whereby in this phase, reflection, evaluation, and instructional refinement were emphasised. These adaptive practices are mostly visible during the Elaborate and Evaluate phases of the 5E model, where these adjustments were informed by student engagement and learning feedback. Together, these alignments illustrate how MER and the 5E Instructional Model functioned as a complementary framework that supported the enactment of TPD qualities through flexible lesson planning.

DISCUSSION

This study examined rural primary STEM teachers' perceptions of effective Teacher Professional Development (TPD) qualities and explored how these qualities were enacted through structured lesson planning informed by the MER. The findings revealed three interconnected TPD qualities: self-development and curriculum innovation, teamwork and flexibility, and adaptivity. Collectively, these findings offer a deeper understanding of how TPD qualities are both conceptualised and enacted in rural STEM contexts.

First, the emphasis on self-development and curriculum innovation reflects that STEM teachers conceptualise effective TPD as learning that is directly connected to classroom practices. This finding is consistent with Desimone (2009), who argues that high-quality TPD shapes not only teachers' content knowledge but also their instructional beliefs and classroom practices. In this study, lesson planning emerged as a key mechanism through which teachers translated professional learning into curriculum innovation, supporting the view that professional development is most meaningful within teaching tasks.

The integration of MER with the 5E instructional model provided a structured approach that supported this process. Through the analysis of content structure, MER Component 1 (analysis of content structure), teachers actively restructured STEM content to make it more accessible and meaningful for diverse learners. This finding echoes prior research on the importance of a practice-based framework that links theory and classroom practice, especially where sustained professional development is limited.

Equity emerged as a subtheme within self-development and curriculum innovation, reflecting teachers' ongoing concern for addressing diverse student needs in rural classrooms. STEM teachers' focus on differentiated instruction and inclusive strategies demonstrates an awareness that effective STEM teaching requires equitable learning opportunities for all level students. This finding supports previous research emphasising the importance of equity-oriented professional development in STEM education (Darling-Hammond et al., 2017). By embedding differentiation strategies within structured lesson plans, teachers were able to translate equity principles into concrete classroom practices, particularly during the Explain and Evaluate phases of the 5E model.

The second theme, teamwork and flexibility, corresponds to the social dimension of teacher professional learning. Teachers' accounts highlight collaboration as a central feature of effective TPD. This collective engagement was viewed as essential for refining instructional practices and sustaining motivation. This aligns strongly with sociocultural perspectives on teacher learning, which emphasise professional communities and shared practice as central to instructional improvement (Vescio et al., 2008; Wenger, 1998). In this study, collaborative lesson planning functioned as a shared space for professional dialogue, enabling teachers to collectively analyse and adapt instructional strategies within the constraints of their local contexts.

The findings indicate that teamwork extended beyond the simple exchange of materials or teaching strategies. Teachers described learning from colleagues' experiences to suit their own classroom contexts. This process reflects MER Model Component 2 (Analysis of Teaching and Learning), whereby shared reflection enables teachers to critically examine how pedagogical decisions shape classroom experiences. Within this process, lesson plans functioned as shared observable materials that structured professional conversations, particularly during the Engage and Explore phases of the 5E model.

The third theme, adaptivity, reflects teachers' recognition that effective STEM instruction requires ongoing responsiveness to students and classroom dynamics. STEM teachers emphasised reflective practice and instructional adjustment, alignment with inquiry-oriented and reflective models of professional learning (Bybee et al., 2006). Lesson plan implementation supported adaptive teaching by providing a clear instructional structure. Teachers used student feedback and learning outcomes to inform instructional adjustments, particularly during the Elaborate and Evaluate phases of the 5E model. This aligns with MER Component 3 (Development and Evaluation of Instruction), underscores evidence-based, iterative improvement in teaching practice.

Overall, the findings suggest that effective TPD for rural STEM teachers is characterized by practice-based learning, collaboration, and adaptive teaching, supported through structured lesson planning. By positioning lesson plans as professional learning tools, this study bridges the gap between theory and practice, enabling teachers to enact TPD qualities directly within their classrooms and extending existing literature by illustrating how these qualities can be operationalised through structured instructional frameworks rather than remaining as abstract principles.

CONCLUSION

This study examined rural primary STEM teachers' perceptions of effective TPD qualities and explored how these qualities were enacted through structured lesson planning informed by the MER. The findings show that STEM teachers in this study perceived effective TPD as practice-based, collaborative, and adaptive, highlighting the importance of professional learning that is embedded within everyday teaching and learning activities.

By integrating MER with the 5E instructional model, this study demonstrates how designed lesson planning can function as a mechanism for professional learning rather than solely as an instructional tool. Through the three main themes: collaborative planning, reflective enactment, and instructional adaptation, STEM teachers were able to translate TPD qualities into daily classroom practice in ways that were responsive to their local contexts. Where access to sustained training opportunities may be limited in rural schools, this approach offers a context-sensitive alternative to stand-alone professional development programmes.

This study contributes to STEM teacher professional development literature by illustrating how TPD qualities can be joined through a structured instructional framework. Instead of viewing professional development as an external programme, this study suggests that professional learning can be embedded within lesson planning to support teachers' ongoing professional growth and instructional decisions. However, the findings are based on a small group of rural primary STEM teachers and should be interpreted within this context. Therefore, the results cannot be generalized to all educational settings.

The findings are based on a specific group of rural primary STEM teachers and may not be directly generalisable to other contexts, particularly urban or secondary school settings. Future research could build on this work by investigating the longitudinal impact of lesson plan-based professional development on teachers' instructional practices and student learning outcomes, as well as by applying the MER-informed framework in different educational contexts. Overall, this study underscores the value of contextually practice-embedded approaches to professional development for supporting integrated STEM teaching in rural primary schools.

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APPENDIX A: SCIENCE LESSON PLAN

Week: 12	**Day**: Wednesday	**Date**: 7/5/2025
Class	1 Perdana	
No. of Student	32	
Time	9.00-10.00 A.M	
Subject	Year 1 Science	
Theme	Earth and Space	
Topic	9.Earth	
Content Standard	9.1 Surface of Earth	
Learning Standard	9.1.1 State the surface of the Earth, e.g. mountain, beach, hill, valley, river, pond, lake and sea.	
Learning objective	At the end of the lesson, students will be able to: 1. Identify at least five examples of the Earth's surface (mountain, beach, hill, valley, river, pond, lake, sea) correctly through observation and discussion. 2. Differentiate between land and water surfaces using pictures, videos, and physical materials (sand, stones, water). 3. Classify surfaces of the Earth into *land* and *water* categories using group activities and sorting tasks.	
Prior Knowledge	Students have observed different places in their daily life (e.g., beach, field, playground, pond) but may not yet know their scientific names.	
Science Attitudes and Values	1. **Observation** – Use senses carefully to observe the characteristics of land and water surfaces (e.g., rough, smooth, wet, dry). 2. **Cooperation** – Work together in groups while exploring and classifying pictures or materials. 3. **Appreciation of the Environment** – Appreciate the beauty and importance of natural features like hills, rivers, and beaches. 4. **Reflection** – Think about what they have learned and how it relates to their everyday surroundings.	

Presentation & Time	Teacher's Activities	Students' Activities	Components of MER	Remarks
Set Induction (±5 minutes) **Introduction of Lesson** **Engagement**	- Teacher shows pictures or short videos of different surfaces (mountain, river, sea, hill, pond) found in the local area. - Teacher asks: "What do you see in these pictures?" and "Have you seen places like these near your home?" - Teacher explains that today's lesson is about the different surfaces of the Earth.	- Students observe the pictures and respond to the teacher's questions. - Students share examples of nearby land and water surfaces they have seen (e.g., hill behind the school, pond near their home).	Component 1 – Contextualizing content to the local environment (linking abstract ideas to familiar experiences).	Teaching aids: Pictures, video clips, flashcards. EL: Contextual and reflective teaching.

Step 1 (±10 minutes) **Hands-on activity** **Exploration**	- Teacher provides a tray filled with sand, stones, and a small bowl of water to represent land and water surfaces. - Teacher invites students to touch, feel, and describe what they observe. - Teacher guides students to differentiate between land and water surfaces.	- Students explore materials and describe what they feel (rough, smooth, wet, dry). - Students classify examples as "land" or "water."	Component 2 – Hands-on exploration to construct understanding (constructivist learning).	Teaching aids: Tray, sand, stones, bowl of water. TPD: Application of inquiry-based and sensory learning strategies.
Step 2 (±10 minutes) **Lesson Content** **Explanation**	- Teacher introduces the key terms: mountain, hill, valley, beach, river, pond, lake, and sea. - Teacher displays labelled pictures and explains each surface type. - Teacher reinforces learning through repetition and simple comparisons (e.g., "A hill is smaller than a mountain").	- Students observe, listen, and repeat the names of each surface. - Students give examples of where they have seen these surfaces before.	Component 2 – Analysis of teaching and learning through guided explanation and questioning.	Teaching aids: Charts, flashcards, real images. EL: Teacher models facilitative leadership and scaffolds understanding.

Step 3 (±10 minutes) **Elaboration**	- Teacher divides students into small groups. - Each group receives mixed picture cards of land and water surfaces. - Teacher asks them to sort and paste into two columns: "Land Surfaces" and "Water Surfaces." - Teacher monitors and guides each group.	- Students discuss in groups and sort the pictures correctly. - Students share their group work with the class.	Component 3 – Development and evaluation of instruction through collaborative tasks.	TPD: Collaborative learning promotes peer teaching and leadership. EL: Encourages teamwork and responsibility.

Step 4 (±10 minutes) **Evaluation**	- Teacher reviews the lesson by asking oral questions: "What are examples of land surfaces?" "What are examples of water surfaces?" - Teacher gives a short worksheet or matching activity to check understanding. - Teacher reflects on which surfaces were easily or poorly identified for future improvement.	- Students answer teacher's questions. - Students complete the worksheet individually. - Students reflect on what they have learned today.	Component 3 – Reflective evaluation of student learning and teaching effectiveness.	EL: Teacher reflects and adjusts the lesson based on student feedback. TPD: Continuous improvement through reflection. Assessment: Oral questioning, worksheet.