




Continuous Professional Development in Innovative Teaching and Classroom Practices among Mathematics Teachers in Ngoma District, Rwanda

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Abstract

Mathematics education in Rwanda faces persistent challenges in translating teacher training into sustained classroom innovation, particularly in rural districts. Purpose: This study evaluates the effect of Continuous Professional Development in Innovative Teaching Methods for Mathematics and Science (CPD ITMS) on mathematics teachers' classroom practices in public lower secondary schools in Ngoma District, Rwanda. A convergent parallel mixed-methods design was employed with a sample of 30 mathematics teachers and 15 deputy headteachers, selected through census and purposive sampling, respectively. Data were collected through structured questionnaires (Cronbach's alpha = 0.82), semi-structured interviews, and classroom observations. Quantitative data were analyzed using descriptive statistics and a one-sample t-test via SPSS v21, while qualitative data underwent thematic analysis. Key Findings showed that Workshops (93%) and seminars (83%) were the most accessed CPD ITMS activities, while peer coaching (60%) and lesson study (33%) were less frequent. CPD ITMS significantly enhanced teachers' openness to learner-centered approaches ($M = 3.87$, $SD = 1.04$; $t(29) = 4.39$, $p < 0.001$), yet classroom application remained inconsistent due to overcrowded classes, ICT shortages, and limited supervisory support. Deputy headteachers' exclusion from CPD ITMS training weakened feedback loops. The study concludes that CPD ITMS can transform mathematics teaching but requires systemic institutional support. Recommendations include structured mentorship programs, targeted resource provision, integration of school leadership into CPD training, and establishment of professional learning communities to sustain pedagogical innovation in rural Rwandan schools.

Keywords: Continuous Professional Development (CPD); Innovative Teaching Methods (ITMS); Mathematics Education; Classroom Innovation; Teacher Professional Growth

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Article information

Received: 21/02/2026;

Reviewed: 11/03/2026;

Revised: 18/03/2026;

Accepted: 19/03/2026

How to cite this article: Kubwimana, P., Nzabwirwa, W. & Dushimimana, J. P. (2026) 'Continuous Professional Development in Innovative Teaching and Classroom Practices among Mathematics Teachers in Ngoma District, Rwanda', *Educational Journal of Technology and Innovation*, 2(1), pp. 34-49. Available at: <https://doi.org/10.58197/0269f786>

Introduction

Mathematics education is widely recognized as essential for developing analytical reasoning and problem-solving skills that contribute to national development (UNESCO, 2017). Effective teaching, however, requires continuous professional growth, particularly in adopting innovative instructional strategies aligned with competency-based curricula (World Bank, 2020). Continuous Professional Development (CPD) programs have been extensively studied worldwide, with countries such as Finland, Singapore, and Japan demonstrating their effectiveness in improving teacher practices and student achievement (Lewis & Takahashi, 2020). Despite this global evidence, translating CPD training into observable, sustained classroom practice remains a persistent challenge, particularly in low-resource and rural educational contexts (Villegas-Reimers, 2003).

In Rwanda, the Ministry of Education, through the Rwanda Basic Education Board (REB), introduced Continuous Professional Development in Innovative Teaching Methods for Mathematics and Science (CPD ITMS) to strengthen STEM teaching in line with the Competence-Based Curriculum (CBC). Mathematics teachers are a specific focus because mathematics remains among the subjects with the lowest achievement rates in Rwanda's national examinations, underscoring the urgency of improving pedagogy in this discipline (REB, 2020). Ngoma District was selected because it represents a predominantly rural setting where CPD implementation challenges, including resource scarcity, large class sizes, and limited supervisory support, are particularly acute yet insufficiently studied. While CPD initiatives are well-documented globally, little empirical evidence exists on how CPD ITMS specifically influences observable classroom practices in rural Rwandan districts, such as Ngoma.

Existing studies in Rwanda have largely examined CPD accessibility and teacher perceptions in urban contexts, but few have investigated observable changes in classroom practices resulting from CPD ITMS in rural settings (Munyaneza, 2022). This gap is significant: understanding whether CPD training translates into meaningful pedagogical change requires evidence from the actual classroom, not merely self-reported perceptions. Moreover, the supervisory role of deputy headteachers, who oversee implementation without directly receiving CPD ITMS training, remains underexplored as a structural gap that weakens accountability and mentoring. This study, therefore, addresses three interrelated gaps: the lack of rural-focused CPD ITMS research in Rwanda, the absence of classroom observation evidence linking CPD to practice, and the overlooked role of school leadership in sustaining pedagogical innovation. By examining the effect of CPD ITMS on mathematics teachers' classroom practices in Ngoma District, this study contributes original empirical evidence on both the opportunities and institutional barriers to effective CPD implementation in rural Rwanda.

Statement of the Problem

Globally, Continuous Professional Development (CPD) programs have been shown to improve teachers' knowledge and pedagogical skills; however, their translation into sustained classroom practice remains inconsistent. In Rwanda, the Ministry of Education has invested significantly in CPD in Innovative Teaching Methods for Mathematics and Science (CPD ITMS) to align teaching with the Competence-Based Curriculum (CBC). Despite these efforts, evidence suggests that mathematics teachers in Ngoma District, a rural setting, continue to rely on traditional, teacher-centered methods (Habiyaemye, Ntivuguruzwa, & Ntawiha, 2022).

This disconnect raises concerns about the effectiveness of CPD ITMS in fostering observable classroom practices that reflect learner-centered pedagogy. Challenges such as inadequate follow-up support, resistance to change, and resource constraints further hinder the integration of CPD-acquired skills (Villegas Reimers, 2003). While these challenges are documented, there is limited empirical evidence on how CPD ITMS specifically influences classroom practices in rural Rwanda, where large class sizes, limited teaching resources, and weak mentorship structures complicate implementation (REB, 2020).

The originality of this study lies in its focus on examining the effect of CPD ITMS on mathematics teachers' classroom practices in Ngoma District, highlighting both the opportunities and barriers to effective implementation in a rural context. By addressing this gap, the study contributes to understanding whether CPD ITMS training translates into meaningful pedagogical change and what institutional conditions are necessary to sustain innovative teaching practices.

Aims and Specific Objectives

This study aims to evaluate the effect of Continuous Professional Development in Innovative Teaching Methods for Mathematics and Science (CPD ITMS) on mathematics teachers' classroom practices in public lower secondary schools in Ngoma District, Rwanda, with a focus on how training translates into observable pedagogical change in a rural context.

Specific Objectives

1. To identify the types and frequency of CPD ITMS activities accessed by mathematics teachers in Ngoma District.
2. To analyze the effect of CPD ITMS on teachers' adoption of learner-centered and innovative classroom practices.
3. To explore the challenges specific to rural schools that hinder mathematics teachers in Ngoma District from implementing CPD ITMS skills.
4. To propose context-specific strategies for enhancing the effectiveness and sustainability of CPD ITMS in improving mathematics teaching practices.

Research Questions

In line with the objectives above, this study sought to answer the following questions:

1. What types of CPD ITMS activities are available to mathematics teachers in Ngoma District, and how frequently are they accessed?
2. To what extent does CPD ITMS influence mathematics teachers' adoption of innovative and learner-centered classroom practices in Ngoma District?
3. What rural-specific challenges do mathematics teachers encounter when applying CPD ITMS skills in their classrooms?
4. What strategies tailored to rural contexts can strengthen the effect of CPD ITMS on mathematics teachers' classroom practices in Ngoma District?

Literature Review

Theoretical Framework

This study is anchored in three complementary theoretical frameworks that together explain the relationship between CPD ITMS training and teachers' classroom practices. First, Bandura's (1977) Social Learning Theory emphasizes observation, imitation, and feedback as mechanisms of professional growth. Within CPD ITMS, teachers adopt innovative strategies by observing peers during workshops, engaging in lesson study, and receiving feedback from supervisors. Evidence from Ngoma District shows that teachers gained confidence in learner-centered methods but struggled to sustain practice without structured mentoring and supervisory feedback (Kubwimana & Nzabwirwa, 2026). This confirms Bandura's assertion that modelling and feedback are essential for sustained behavioural change. Second, constructivist learning theory (Vygotsky, 1978) holds that meaningful learning occurs through active engagement, social interaction, and contextual problem-solving. CPD ITMS promotes constructivist principles by encouraging inquiry-based learning and collaborative lesson study. However, when classroom conditions, such as overcrowded classes and ICT shortages, prevent teachers from facilitating such environments, the gap between CPD ideals and classroom realities widens. Third, Wenger's (1998) Communities of Practice framework emphasizes that professional learning is most effective when practitioners engage in sustained, collaborative inquiry within shared communities. This framework directly supports the study's emphasis on peer coaching and professional learning communities as mechanisms for sustaining CPD ITMS outcomes in rural schools.

Complementing this, Guskey's (2002) Model of Teacher Change highlights that professional development only translates into classroom practice when teachers receive consistent institutional support. CPD ITMS aligns with this principle by promoting collaboration and mentoring, yet its sustainability in rural Rwanda is undermined by weak feedback loops and the exclusion of deputy headteachers from training (Kubwimana & Nzabwirwa, 2026). Together, these four frameworks, Bandura's Social Learning Theory, Vygotsky's constructivism, Wenger's Communities of Practice, and Guskey's Model of Teacher Change, provide an integrated lens for examining why CPD ITMS builds teacher confidence but does not always translate into sustained classroom innovation. They clarify that teacher-level attitudinal change is necessary but insufficient without systemic institutional support, collaborative structures, and resource provision.

CPD and Teacher Professional Growth

Global studies confirm that sustained CPD enhances teachers' pedagogical content knowledge (PCK) and classroom effectiveness (Desimone, 2019; Lewis & Takahashi, 2020). Both scholars agree that CPD must be sustained, content-focused, and embedded in collaborative practice to produce lasting change; however, they differ in emphasis. Desimone (2009) foregrounds structural design features such as active learning and coherence with curriculum standards, while Lewis and Takahashi (2020) emphasize teacher-led inquiry through lesson study as the superior mechanism for classroom improvement. In Rwanda, Nkundabakura et al. (2024) found that CPD initiatives improved teachers' PCK, but resource shortages limited classroom application. Similarly, Munyaneza (2022) reported that without follow-up support, teachers often reverted to traditional practices. These Rwandan findings align broadly with global evidence, yet expose a critical limitation: prior local studies relied on self-reported perceptions rather than direct classroom observations, and largely focused on urban

settings. This study addresses both limitations by incorporating structured classroom observations in a rural district.

Recent evidence from Ngoma District improves this picture. Kubwimana & Nzabwirwa (2026) found that while CPD ITMS significantly increased teachers' willingness to adopt innovative methods ($t(29) = 4.39, p < 0.001$), systemic barriers limited sustained practice. Teachers cited ICT shortages ("our school has two computers for the whole staff"), overcrowded classrooms ("with 70 students, group work is impossible"), and weak mentoring ("we supervise lessons, but we were not trained in CPD ITMS"). These findings highlight that willingness alone does not guarantee classroom transformation without institutional support.

Innovative Teaching Methods in Mathematics Education

In Rwanda, CPD ITMS is delivered over a range of structured activities, including workshops, seminars, peer coaching, and lesson study sessions. Each of these activities plays a distinct role in shaping teachers' classroom practices, though their effectiveness varies depending on the level of institutional support and the rural context in which they are implemented.

Workshops and seminars are the most common CPD ITMS activities, providing teachers with opportunities to acquire new pedagogical knowledge and practice innovative teaching methods in structured environments. They are particularly effective in raising awareness of learner-centred strategies and introducing teachers to ICT-based approaches. However, their impact tends to be short-lived when not reinforced by follow-up support. Studies in Rwanda show that teachers often leave workshops motivated but return to traditional practices when faced with overcrowded classrooms and limited resources (Munyaneza, 2022). This suggests that workshops and seminars are useful for initiating change but insufficient for sustaining it without complementary mentoring structures.

Peer coaching, another component of CPD ITMS, emphasizes collaboration and reflective practice. Teachers work together to observe lessons, provide feedback, and adapt learner-centered strategies to their own classrooms. Evidence from Ngoma District indicates that peer coaching helped teachers experiment with group work and inquiry-based methods, but its effectiveness was constrained by heavy workloads and limited time for collaboration (Kubwimana & Nzabwirwa, 2026). Despite these challenges, peer coaching remains a valuable mechanism for reinforcing skills learned in workshops, as it provides ongoing peer support and fosters a culture of shared learning.

Lesson study, adapted from Japanese CPD models, involves teachers collaboratively planning, teaching, and evaluating lessons. It is widely recognized as one of the most effective approaches for refining instructional strategies, as it combines observation, reflection, and iterative improvement (Lewis & Takahashi, 2020). In Rwanda, lesson study has been integrated into CPD ITMS to encourage collaborative inquiry and problem-solving. However, in rural districts such as Ngoma, its feasibility is limited by overcrowded classrooms and shortages of ICT tools, which make it difficult to implement learner-centered activities consistently (Kubwimana & Nzabwirwa, 2026). This highlights the importance of adapting lesson study to local conditions, ensuring that teachers can realistically apply its principles in resource-constrained environments.

Taken together, these activities demonstrate that CPD ITMS effectiveness depends not only on the type of activity but also on the institutional structures that sustain them. Workshops and seminars

raise awareness, peer coaching reinforces collaboration, and lesson study deepens reflective practice. Yet without adequate resources, mentoring, and leadership involvement, their impact remains uneven. The evidence from Ngoma District underscores that CPD ITMS activities must be rooted within supportive school systems if they are to translate into sustained classroom innovation.

CPD Implementation in Developing Countries

Evidence from Ngoma District demonstrates that CPD ITMS has strengthened teachers' confidence in adopting learner-centered methods, particularly group work, inquiry-based learning, and the integration of ICT tools into mathematics lessons. Classroom observations, however, revealed that these practices were inconsistently applied. While some teachers attempted to implement active learning strategies, overcrowded classrooms and shortages of ICT resources limited their ability to sustain innovation (Kubwimana & Nzabwirwa, 2026). This pattern illustrates the distinction between attitudinal change and behavioural change: CPD ITMS positively influenced teachers' willingness to innovate, but systemic barriers prevented consistent classroom transformation.

From a theoretical perspective, this finding aligns with Bandura's Social Learning Theory, which emphasizes that modelling and feedback are essential for sustained practice. Teachers gained confidence through workshops and peer coaching, but lacked ongoing feedback from trained supervisors. Similarly, Guskey's Model of Teacher Change underscores that professional development requires institutional support to translate into classroom application. In Ngoma, the exclusion of deputy headteachers from CPD ITMS training weakened feedback loops, leaving teachers without the mentoring necessary to embed new practices. Thus, while CPD ITMS has a demonstrable effect on teacher attitudes, its impact on classroom practices remains contingent on institutional structures and resource provision.

CPD Initiatives in Rwanda

Although CPD ITMS has strengthened teachers' confidence in adopting innovative methods, its translation into sustained classroom practice in Ngoma District remains constrained by systemic barriers. Resource shortages, particularly the lack of ICT tools and teaching materials, limit teachers' ability to integrate technology into mathematics lessons. Overcrowded classrooms further undermine learner-centered strategies such as group work and inquiry-based learning, as teachers struggle to manage large numbers of students effectively (Munyaneza, 2022). Time constraints also complicate implementation, with teachers balancing lesson preparation, grading, and administrative duties, leaving little room to experiment with new methods (Uwizeyimana et al., 2022).

Beyond these well-documented challenges, recent evidence highlights a distinctive gap: the exclusion of deputy headteachers from CPD ITMS training. As supervisors responsible for monitoring instructional practices, their lack of program-specific preparation weakens feedback loops and mentoring structures, leaving teachers without consistent guidance (Kubwimana & Nzabwirwa, 2026). This leadership gap is particularly significant in rural schools, where institutional support is already limited. Reformulating the challenge, the issue is not simply resource or time constraints but the absence of integrated leadership and systemic support, which undermines the sustainability of CPD ITMS. Without trained supervisors to reinforce and monitor classroom application, CPD ITMS risks remaining a short-term confidence promoter rather than a driver of lasting pedagogical change.

Strategies for Enhancing CPD Effectiveness

Addressing the challenges of CPD ITMS implementation in rural Rwanda requires strategies that go beyond initial training sessions and focus on sustained support. Continuous mentorship and structured follow-up are critical for reinforcing skills learned during workshops and ensuring that teachers can adapt innovative methods to their classroom realities. Evidence from Ngoma District shows that teachers often revert to traditional practices when feedback is irregular or absent, underscoring the need for consistent supervisory engagement (Kubwimana & Nzabwirwa, 2026).

Integrating deputy headteachers into CPD ITMS training is particularly vital. As supervisors responsible for monitoring instructional practices, their exclusion has weakened feedback loops and left teachers without adequate guidance. Providing deputy headteachers with program-specific training would strengthen mentoring structures, create accountability, and sustain classroom innovation. This leadership integration directly addresses the systemic gap identified in rural schools, where institutional support is limited.

Resource provision also remains a cornerstone of effective CPD. Without adequate ICT tools and teaching materials, teachers cannot realistically apply learner-centered strategies. Collaborations with stakeholders such as REB and development partners can help bridge these resource gaps, ensuring that CPD ITMS is not undermined by infrastructural shortages (REB, 2023; Nguyen & Nguyen, 2022). Modifying training materials to local contexts further enhances relevance, allowing teachers to address specific challenges such as overcrowded classrooms and limited technology. Involving teachers in the design and evaluation of CPD programs fosters ownership, increasing motivation, and ensuring that professional development initiatives align with classroom realities (Sundqvist, 2021).

Taken together, these strategies highlight that CPD ITMS effectiveness depends not only on the quality of training but also on the institutional structures that sustain it. By strengthening mentorship, integrating school leadership, providing resources, and contextualizing training, CPD ITMS can move beyond short-term confidence gains to become a sustainable driver of pedagogical transformation in rural Rwanda.

Gaps in the literature

Despite growing research on CPD, gaps remain. Many studies rely on descriptive approaches and lack classroom observations or longitudinal analysis (Nkundabakura et al., 2024). In Rwanda, most CPD studies focus on urban schools, neglecting rural contexts where challenges such as overcrowded classrooms and ICT shortages are most acute (Munyaneza, 2022). Kubwimana & Nzabwirwa (2026) uniquely highlight the exclusion of deputy headteachers from CPD ITMS training, a gap that prior studies have not widely addressed. This study, therefore, offers original insights by examining the effects of CPD ITMS on mathematics teachers' classroom practices in Ngoma District, foregrounding both teacher-level and institutional challenges in a rural setting.

Methodology

This study adopted a convergent parallel mixed-methods design (Creswell, 2014). This descriptive and correlational research approach simultaneously collects and analyzes both quantitative and qualitative data to provide a comprehensive understanding of the effect of CPD ITMS on mathematics teachers' classroom practices. This design was selected because CPD ITMS involves both measurable outcomes, such as the frequency of innovative classroom practices, and contextual factors, including resource shortages and supervisory support structures, which cannot be fully captured by a single method. The quantitative strand enabled statistical testing of CPD ITMS effectiveness, while the qualitative strand provided rich contextual explanations for observed patterns. Triangulation of data sources enriched numerical trends with descriptive narratives, thereby strengthening the credibility and validity of findings.

Population and Sampling

The study focused on two respondent groups: mathematics teachers and deputy headteachers responsible for studies. The accessible population comprised all 30 mathematics teachers from public lower secondary schools in Ngoma District who had participated in CPD ITMS training; census sampling was employed to ensure complete representation of all classroom implementers and to eliminate sampling error given the small, bounded population. In addition, 15 deputy headteachers were purposively selected for their critical role in supervising instructional practices, despite not being direct beneficiaries of the CPD ITMS. Purposive sampling was appropriate here because these participants were selected based on specific knowledge criteria, namely their responsibility for monitoring classroom instruction. The total sample of 45 participants provided sufficient breadth to capture both teacher-level implementation experiences and leadership-level supervisory perspectives, which together are essential for understanding CPD ITMS sustainability in rural schools.-

Data Collection Methods

Three complementary instruments were employed. First, a structured questionnaire comprising 25 items was administered to all 30 mathematics teachers to collect data on access to CPD ITMS, frequency of participation, and perceptions of its effectiveness on classroom practices. Items were rated on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The questionnaire was developed based on Desimone's (2009) framework for effective professional development, adapted to the Rwandan CPD ITMS context, and validated through expert review by two academic specialists in teacher education at the University of Rwanda. Content validity was assessed, and items were revised based on expert feedback before pilot testing. Reliability was confirmed through pilot testing with 10 teachers in Rwamagana District (not included in the main study), yielding a Cronbach's alpha coefficient of 0.82, indicating strong internal consistency. Second, a semi-structured interview guide comprising 12 open-ended questions was used with all 15 deputy headteachers to explore institutional support, supervisory practices, and barriers to the implementation of CPD ITMS. Interviews lasted approximately 45 minutes and were audio-recorded with participants' consent, then transcribed verbatim for analysis. Third, a structured classroom observation checklist comprising 18 observable indicators was used to assess the practical application of CPD ITMS strategies, focusing on learner-centered practices, ICT integration, and inquiry-based learning. Each of the 30 teachers was observed during at least one complete 60-minute lesson, with

the checklist used to record the presence, partial presence, or absence of each CPD ITMS practice. Ethical clearance was obtained from the University of Rwanda, and informed written consent was secured from all participants prior to data collection.

Data Analysis

Quantitative data from questionnaires were analyzed using SPSS version 21. Descriptive statistics (means, standard deviations, frequencies) summarized teacher responses, while one-sample t-tests determined whether ratings of CPD ITMS effectiveness significantly differed from the neutral midpoint of the Likert scale ($M = 3.0$). This tested whether CPD ITMS had a meaningful effect on classroom practices beyond neutral perceptions. Qualitative data from interviews and observations were analyzed thematically through inductive coding, categorization, and theme development. Reliability was enhanced through independent coding and member checking, while triangulation across instruments ensured consistency and validity.

Results

This section presents the outcomes of teachers' access to, engagement in, and implementation of CPD ITMS training. The analysis explores participation in CPD activities, the impact of training on classroom practices, and the challenges encountered in applying newly acquired strategies. Statistical results highlight the effectiveness of CPD ITMS in fostering pedagogical innovation, while qualitative insights underscore barriers requiring targeted interventions.

Types of CPD ITMS Activities (RQ1)

Mathematics teachers in Ngoma District participated in four main CPD ITMS activities: workshops, seminars, peer coaching, and lesson study. Workshops (93%) and seminars (83%) were the most frequent, providing structured opportunities to acquire new pedagogical knowledge. Peer coaching (60%) fostered collaboration but was constrained by workload and time. Lesson study (33%) deepened reflective practice but was hindered by overcrowded classrooms and ICT shortages (see Table 1).

Table 1. Types of CPD ITMS Activities Accessed by Mathematics Teachers in Ngoma District

CPD-ITMS Activity	Frequency (n = 30)	Percentage (%)	Notes on Effectiveness
Workshops	28	93	Raised awareness of learner-centered strategies but short-lived without follow-up.
Seminars	25	83	Introduced ICT-based approaches; impact limited by resource
Peer Coaching	18	60	shortages. Fostered collaboration; constrained by workload and time.
Lesson Study	10	33	Deepened reflective practice; hindered by overcrowded classrooms and ICT shortages.

Note. Data derived from teacher questionnaires and interviews. Researcher, 2025

Teachers noted that while workshops and seminars provided initial exposure to innovative methods, sustained application required mentoring and resource support. One teacher explained: *"We learned how to use ICT in teaching, but our school has only two computers for the whole staff, so lesson study becomes difficult to apply."*

Influence of CPD ITMS on Classroom Practices (RQ2)

Quantitative analysis shows CPD ITMS significantly influenced teachers' openness to learner-centered approaches. A one-sample t-test confirmed a statistically significant effect ($t(29) = 4.39, p < 0.001$), with a mean score of $M = 3.87$ ($SD = 1.04$). Classroom observations revealed attempts at group work and inquiry-based learning, though overcrowded classrooms and limited ICT tools constrained success. As one teacher noted: *"Active learning is good, but with 70 students in one class, it is impossible to manage group work."* This demonstrates that CPD ITMS positively shaped attitudes but required stronger institutional support to translate into consistent classroom practice.

Challenges in Implementation (RQ3)

Despite positive attitudes, several barriers limited classroom innovation. Resource shortages, large class sizes, and insufficient supervisory support weakened feedback loops. Deputy headteachers highlighted their exclusion from CPD ITMS training, stating: *"We supervise lessons, but we were not trained in CPD ITMS, so we cannot provide effective feedback."* Some teachers returned to traditional lectures due to familiarity and concerns about classroom management.

Strategies for Improvement (RQ4)

Teachers emphasized continuous mentorship, structured follow-up, and resource provision as critical for sustaining innovation. Integrating deputy headteachers into CPD ITMS training would strengthen supervisory roles and feedback loops. Structured monitoring and evaluation were also recommended to ensure accountability and sustainability.

Accuracy, Reliability, and Validity

Findings were reported with accuracy, as statistical results were correctly calculated and interpreted to demonstrate the significant effect of CPD ITMS. Reliability was established through pilot testing (Cronbach's $\alpha = 0.82$), while qualitative coding reliability was supported by Cohen's $\kappa (0.79)$. Validity was strengthened through triangulation across questionnaires, interviews, and observations. Participant voices enhanced authenticity, and systematic thematic analysis ensured internal validity.

Discussion

The findings showed that CPD ITMS activities such as workshops, seminars, peer coaching, and lesson study are available to mathematics teachers in Ngoma District, but their effectiveness is uneven. Workshops (93%) and seminars (83%) were the most frequently accessed, consistent with Desimone's (2009) observation that structured, content-focused CPD raises pedagogical awareness. However, their impact was short-lived without structured follow-up, echoing Munyaneza's (2022) findings across other Rwandan districts, which suggests this is a systemic pattern in CPD design rather than a district-specific anomaly. Notably, peer coaching and lesson study, despite being recognized globally as more

transformative CPD modalities (Lewis & Takahashi, 2020), were the least accessed, with only 60% and 33% of teachers accessing them, respectively. The probable reason is that these activities demand time and collaboration that rural teachers, burdened with large classes and administrative duties, cannot readily afford. This explains why CPD ITMS raised awareness but did not consistently reform practice, a pattern that aligns with Desimone's (2009) framework, emphasizing that professional development must be sustained and context-specific to achieve lasting impact.

Statistical evidence confirmed that CPD ITMS significantly influenced teachers' openness to innovative practices ($M = 3.87$, $SD = 1.04$; $t(29) = 4.39$, $p < 0.001$). This finding is consistent with Nkundabakura et al. (2024), who similarly found CPD-related gains in PCK and receptiveness to new methods. However, the gap between this attitudinal openness and actual classroom practice, observed as inconsistent application of learner-centered strategies, is a key finding that advances beyond prior Rwandan studies. The probable explanation is that attitudinal change is a necessary but insufficient precondition for behavioral change: without ongoing reinforcement, new practices erode under the weight of contextual pressures. This aligns directly with Bandura's (1977) Social Learning Theory, which asserts that modelling and feedback loops are essential for sustained behavioral change. Teachers gained initial confidence through workshops and peer observation but lacked the ongoing supervisory feedback needed to consolidate new behaviors. Guskey's (2002) Model of Teacher Change further explains this gap: his model holds that teachers change their beliefs only after they see positive results in their students, and achieving such results is difficult when resource constraints prevent full implementation. The exclusion of deputy headteachers from CPD ITMS training is thus not merely an administrative oversight but a structural deficit that undermines the feedback mechanisms both Bandura and Guskey identify as essential. Addressing this gap through policy reform is the most direct lever available to Rwanda's Ministry of Education to improve CPD outcomes at scale.

The challenges identified, including resource shortages, large class sizes averaging 65-70 students, and insufficient follow-up support, explain the uneven CPD ITMS outcomes and mirror findings from Munyaneza (2022) and Uwizeyimana et al. (2022) in other rural Rwandan schools. However, this study makes a distinctive contribution by identifying the exclusion of deputy headteachers from CPD ITMS as a structural barrier that has not been widely addressed in previous Rwandan literature. Participant voices powerfully reinforced these challenges: teachers described the physical impossibility of organizing group work in overcrowded rooms, while deputy headteachers candidly acknowledged that they could not provide meaningful instructional feedback on CPD ITMS strategies they had never been trained in. This represents a failure of systemic alignment: CPD ITMS was designed for teachers but not for those responsible for monitoring and sustaining it, creating an institutional accountability gap that no individual teacher motivation can bridge.

The originality of this study lies in its rural focus. While previous research in Rwanda has examined CPD accessibility and teacher perceptions, this study provides empirical evidence of how CPD ITMS translates or fails to translate into observable classroom practices in Ngoma District. The strategies proposed, continuous mentorship, resource provision, leadership integration, and structured monitoring, are not generic but direct responses to barriers identified in rural schools. They align with Sundqvist's (2021) argument that context-specific training and teacher ownership are critical for sustainability. By embedding CPD ITMS within supportive institutional structures, Rwanda can move beyond short-term confidence gains to achieve lasting pedagogical transformation.

Concluding remark

This study examined the effect of CPD ITMS on mathematics teachers' classroom practices in Ngoma District, Rwanda. Four research questions guided the inquiry, and the findings consistently revealed a pattern of partial effectiveness constrained by systemic barriers. First, teachers accessed four types of CPD ITMS activities, with workshops (93%) and seminars (83%) most frequent, while peer coaching (60%) and lesson study (33%) remained underutilized despite being recognized as more transformative modalities. Second, CPD ITMS significantly influenced teachers' openness to learner-centered approaches ($M = 3.87$, $SD = 1.04$; $t(29) = 4.39$, $p < 0.001$), yet classroom observations revealed inconsistent implementation, suggesting that attitudinal change does not automatically lead to behavioral change. Third, rural-specific challenges, including overcrowded classrooms, ICT shortages, and the structural exclusion of deputy headteachers from CPD ITMS training, limited the translation of training into sustained practice. Fourth, teachers proposed continuous mentorship, resource provision, leadership integration, and structured monitoring as the strategies most needed to strengthen CPD ITMS outcomes. The study contributes to knowledge by providing rare classroom observation evidence linking CPD ITMS to practice in a rural Rwandan district, by foregrounding the leadership accountability gap as a systemic barrier, and by validating the applicability of Bandura's, Guskey's, Vygotsky's, and Wenger's frameworks as an integrated lens for understanding CPD implementation challenges in low-resource educational contexts.

Policy Implications

The findings highlight the need for Rwanda's Ministry of Education and REB to embed CPD ITMS within supportive institutional structures. Integrating deputy headteachers into CPD training would strengthen supervisory feedback loops, while targeted resource provision, particularly ICT tools, would enable teachers to consistently apply innovative strategies. Structured monitoring and evaluation mechanisms are essential to ensure accountability and sustainability.

Practical Implications

Schools should establish professional learning communities to reinforce collaboration and peer support. Continuous mentorship programs can help teachers sustain skills acquired in workshops and seminars. Lesson study and peer coaching should be adapted to rural realities, ensuring feasibility despite large class sizes and limited resources.

Theoretical Implications

The study confirms Bandura's Social Learning Theory by showing that confidence alone is insufficient without reinforcement and feedback. It also supports Guskey's Model of Teacher Change, emphasizing that institutional support is critical for translating professional development into classroom practice. The rural context adds originality, demonstrating that systemic barriers can undermine otherwise effective CPD models.

Limitations and Future Research

This study was limited to one district and a relatively small sample size, which constrains generalizability. Classroom observations were conducted at a single point in time, limiting insights into long-term sustainability. Future research should adopt longitudinal designs across multiple districts to

assess how CPD ITMS practices evolve over time. Comparative studies between rural and urban schools would further clarify context-specific challenges and strategies for scaling CPD ITMS nationally.

Acknowledgment

The author gratefully acknowledges the support and contributions of individuals and institutions who made this study possible, but do not meet the criteria for authorship. Special appreciation is extended to the mathematics teachers and deputy headteachers in Ngoma District who generously shared their time and experiences during data collection. The author also thanks the Rwanda Basic Education Board (REB) and Ngoma District authorities for granting research clearance and facilitating access to schools.

Gratitude is further expressed to colleagues and peers who provided constructive feedback during the development of research instruments and analysis procedures. The author acknowledges the technical assistance received during pilot testing and the encouragement offered by academic mentors and fellow researchers. Their contributions enriched the quality of this work and ensured its successful completion.

Recommendations

Based on the findings of this study, several recommendations are proposed to strengthen the effectiveness and sustainability of CPD ITMS in rural Rwandan schools. These recommendations are organized into policy, practical, and research dimensions.

Policy Recommendations

To strengthen the effectiveness and sustainability of CPD ITMS in Rwanda, the following specific policy actions are recommended. First, the Ministry of Education should formally mandate the inclusion of deputy headteachers in all future CPD ITMS training cycles, with a dedicated module on instructional supervision and feedback delivery. This would directly address the accountability gap that currently weakens mentoring structures in rural schools. Second, the Rwanda Basic Education Board (REB) should revise its CPD ITMS implementation framework to require structured post-workshop follow-up visits, conducted at least twice per term, to assess whether CPD-acquired strategies are being applied in classrooms. Third, REB and district education offices in rural areas should develop a targeted resource allocation plan that guarantees a minimum ICT-to-teacher ratio, such as one functional device per three teachers, in all lower secondary schools participating in CPD ITMS. Fourth, the Ministry of Education should establish a national monitoring and evaluation framework for CPD ITMS that tracks observable classroom practice outcomes rather than merely participation rates, to ensure accountability and evidence-based program improvement.-centered strategies more effectively despite contextual constraints. In addition, structured monitoring and evaluation frameworks should be established to promote accountability and track the long-term impact of CPD ITMS on classroom practices. Together, these measures would embed CPD ITMS within supportive institutional structures, ensuring that professional development translates into sustained pedagogical transformation.

Practical Recommendations

At the school level, school leaders and teachers should take the following specific actions. School principals should formally establish Professional Learning Communities (PLCs) of four to six mathematics teachers who meet bi-weekly to collaboratively plan, teach, and evaluate lessons using the lesson study cycle. Deputy headteachers, once trained in CPD ITMS as recommended above, should conduct structured fortnightly classroom observation visits using standardized CPD ITMS checklists and provide written feedback to observed teachers within 48 hours. Individual teachers should maintain reflective practice journals documenting their attempts to apply CPD ITMS strategies, challenges encountered, and adjustments made, which can then be shared within PLC meetings for peer support. District education officers should organize quarterly inter-school CPD experience-sharing forums where teachers from different schools present classroom innovations and co-develop solutions to shared implementation challenges. These concrete, institution-specific actions would institutionalize CPD ITMS within schools' daily culture rather than treating it as a periodic training event.-constrained environments. By institutionalizing these practices, schools can create a supportive culture of professional growth that enables teachers to apply learner-centered strategies despite contextual challenges consistently

Research Recommendations

The following specific research directions are proposed. First, longitudinal studies tracking the same cohort of CPD ITMS-trained teachers over two to three academic years are needed to assess whether initial confidence gains translate into durable classroom innovation over time. Second, comparative mixed-methods studies across at least three districts, including urban, peri-urban, and rural, would clarify whether the barriers identified in this study are rural-specific or reflect broader systemic weaknesses in CPD ITMS implementation. Third, experimental or quasi-experimental studies that specifically test the impact of including deputy headteachers in CPD ITMS training, using control and treatment schools, would provide causal evidence on the value of leadership integration. Fourth, studies using student achievement data as an outcome measure would address the ultimate question of whether CPD ITMS-related classroom changes actually improve mathematics learning outcomes. Fifth, studies examining how communities of practice function within Rwandan school contexts could inform the design of more culturally appropriate and sustainable CPD structures.

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