



Teachers' Perceptions of Continuous Professional Development in Innovative Mathematics and Science Teaching

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Article Info	Abstract
Received October 15, 2024	This qualitative study investigated teachers' perceptions of the Continuous Professional Development Certificate in Innovative Teaching of Mathematics and Science (CPD ITMS) in a selected public secondary school in Rwanda. The program was introduced to address longstanding challenges in STEM education, including outdated pedagogical practices, limited teacher training, and poor student engagement in mathematics and science subjects. Prior to the implementation of CPD ITMS, many teachers lacked the necessary skills to adopt innovative teaching methods, which negatively impacted student performance in STEM disciplines. Through interviews with four teachers, this study revealed that CPD ITMS positively influenced pedagogical skills and student outcomes by promoting more interactive and student-centered learning techniques. These improvements directly addressed the initial gaps in teacher preparation and student engagement, offering promising solutions to the challenges facing STEM education in Rwanda. However, the study also identified ongoing barriers such as time constraints and resource limitations, which delay the full implementation of the program. The findings emphasized the need for sustained school support and targeted policy reforms to enhance the effectiveness of CPD ITMS, thereby advancing STEM education. Addressing these challenges through clear policy directives and resource allocation is critical for future progress.
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INTRODUCTION

Continuous Professional Development (CPD) plays a crucial role in enhancing the quality of education by equipping teachers with the necessary skills and knowledge to adapt to evolving educational demands. Research shows that effective CPD programs can significantly improve teaching practices, which in turn, positively impacts student learning outcomes (Al Ghamdi, 2015; Abakah et al., 2022). In the context of Rwanda, a country committed to education reform, CPD has been positioned as a key driver in achieving its ambitious educational goals.

One of the significant CPD initiatives introduced in Rwanda is the Continuous Professional Development Certificate in Innovative Teaching of Mathematics and Science (CPD ITMS) (UR-CE, 2023). This program was designed to address specific challenges faced by mathematics and science teachers in secondary schools, including outdated teaching methods, limited training in technological integration, and insufficient access to current subject-specific content. Before the introduction of CPD ITMS, these issues contributed to low student engagement and poor performance in STEM subjects, underlining the need for targeted professional development to modernize teaching practices.

The CPD ITMS program aims to improve the teaching of mathematics and science by equipping teachers with innovative pedagogical approaches, integrating technology into classrooms, and providing up-to-date content in these subjects. Its overarching goal is to raise the quality of education in Rwanda's public secondary schools by fostering innovation and excellence in teaching (UR-CE, 2023).

However, despite its implementation, there remains limited understanding of how teachers perceive the relevance, effectiveness, and impact of the CPD ITMS program on their professional practices and student learning outcomes. Research from other contexts highlights the importance of understanding teacher perceptions to optimize professional development programs and ensure they meet teachers' needs (Al Ghamdi, 2015; Abakah et al., 2022). Yet, in Rwanda, this crucial area of inquiry has been underexplored, delaying the potential refinement of the CPD ITMS program to better align with the expectations and experiences of teachers.

Recognizing the central role that teachers play in shaping educational quality and student success, this study aims to investigate Rwandan teachers' perceptions of the CPD ITMS program. By exploring their views on the program's relevance, effectiveness, and influence on teaching practices, the study seeks to inform both policy and practice. Furthermore, it aims to contribute to the growing body of literature on CPD in the Rwandan context, offering insights that could guide the refinement of the CPD ITMS program and inform similar initiatives globally.

A review of the literature revealed a growing interest in teacher professional development programs and their impact on educational outcomes worldwide. CPD is widely recognized as essential in the field of education, particularly in the teaching of mathematics and science (Niyibizi & Mutarutinya, 2024). The study highlighted the positive impacts of CPD on teachers' pedagogical practices, content knowledge, and ultimately, student outcomes (Sum et al., 2018). Teachers generally perceive CPD as a crucial component of their professional growth, enabling them to stay updated with the latest educational strategies, technologies, and curriculum changes (Fraser et al., 2007). This ongoing learning process helps them to effectively address the diverse needs of their students, raising a more dynamic and engaging learning environment.

Studies have highlighted the importance of continuous learning opportunities for teachers to adapt to changing educational paradigms and improve student achievement (Yurkofsky et al., 2020; Ngenzi et al., 2021; Nunguye et al., 2022). Research by Calleja (2016) emphasizes that teachers value CPD opportunities that are directly related to their classroom practices and subject areas. For mathematics and science teachers, in particular, CPD programs that focus on deepening their

understanding of complex concepts and enhancing their instructional techniques are seen as highly beneficial. These programs not only help teachers improve their subject matter expertise but also provide practical strategies for effectively communicating these concepts to students, thereby improving student engagement and achievement in these critical subjects.

Furthermore, studies such as those conducted by Yan and Tan (2021) indicate that teachers perceive CPD as essential for adapting to new educational standards and assessment methods. In the rapidly evolving fields of mathematics and science, staying abreast of the latest advancements and pedagogical approaches is crucial. Teachers report that CPD helps them to align their teaching practices with current standards, such as the Next Generation Science Standards (NGSS) or Common Core State Standards (CCSS) in mathematics, ensuring that their instruction meets the required benchmarks and prepares students for future academic and career challenges.

Additionally, collaborative CPD models, such as professional learning communities (PLCs) and peer coaching are particularly valued by teachers for their role in fostering a supportive professional network. Research by Nasreen and Odhiambo (2018) shows that teachers appreciate the opportunity to engage in collaborative problem-solving, share best practices, and receive feedback from their peers. This collaborative aspect of CPD not only enhances individual teaching practices but also contributes to a positive school culture that prioritizes continuous improvement and collective responsibility for student success.

Moreover, the perceived importance of CPD is also linked to teachers' professional identity and job satisfaction. Studies, such as those by Mlambo et al. (2021), reveal that teachers who engage in regular CPD feel more confident and competent in their roles, which in turn enhance their job satisfaction and motivation. For mathematics and science teachers, who often face the challenge of keeping up with rapid advancements in their fields, CPD serves as a critical tool for maintaining their professional relevance and enthusiasm for teaching. This ongoing professional growth ensures that they inspire and effectively educate their students, contributing to a more robust and innovative educational system.

Furthermore, in the context of Rwanda, research on teacher professional development initiatives such as CPD ITMS is limited but essential for understanding the effectiveness of such programs in improving teaching quality and student learning outcomes. Previous studies have emphasized the need for context-specific approaches to teacher professional development and the importance of considering teachers' perspectives in program design and implementation (Szelei et al., 2020; Bergmark, 2023). Therefore, exploring teachers' perceptions of CPD ITMS was critical for ensuring its relevance and impact in Rwandan public secondary school.

The theory guiding this study was likely based on the idea that CPD programs significantly impact teaching practices and student learning outcomes. One theory that informed this study was the Professional Development School (PDS) model, which emphasizes ongoing, collaborative learning among teachers to improve instructional practices and student achievement (Whitford & Barnett, 2016). This theory suggests that when teachers engage in structured, sustained, and job-embedded professional development, they are better equipped to meet the various needs of their students and improve learning outcomes.

The study had been guided by this theory in several ways. First, it likely informed the selection of CPD ITMS programs as the focus of the study, as these programs were specifically designed to enhance teachers' instructional technology skills and teaching practices. The PDS model suggests that by improving teachers' technological proficiency and pedagogical strategies, these programs lead to more effective teaching methods and, consequently, improved student learning outcomes in mathematics and science.

Second, the theory likely influenced the research objectives by emphasizing the importance of understanding teachers' perceptions. The PDS model suggests that teachers' beliefs and attitudes play a crucial role in the implementation and effectiveness of professional development programs (Whitford & Barnett, 2016). Therefore, by investigating teachers' perceptions of CPD ITMS programs, the study wished to gain insights into how these programs are perceived by teachers and how these perceptions may influence their effectiveness and impact on teaching practices and student learning outcomes.

Lastly, the theory likely guided the study in framing the research objective and data analysis. The PDS model suggests that effective professional development programs should be ongoing, collaborative, and focused on improving instructional practices (Whitford & Barnett, 2016). Therefore, the study had focused on questions related to the frequency and nature of CPD ITMS programs, the extent of collaboration among teachers, and the specific strategies used to enhance teaching practices and student learning outcomes in mathematics and science. The data analysis had involved identifying patterns and themes in teachers' responses to understand the perceived effectiveness, challenges, and overall impact of CPD ITMS programs.

The relationship between the PDS model and the ITMS CPD program, the theory likely shaped the research objective by emphasizing the importance of sustained, collaborative professional development aimed at enhancing teaching practices. This aligns with the ITMS CPD program's structure, which promotes continuous learning, teamwork, and instructional improvement, reflecting the principles of the PDS model.

The study was guided with the following research objective: To investigate the perceptions of teachers regarding the effectiveness, challenges, and overall impact of CPD ITMS programs in public secondary school in Rwanda, with the purpose of understanding the extent to which these programs contribute to enhancing teaching practices and student learning outcomes in mathematics and science.

RESEARCH METHODS

Research Approach

The research utilized a qualitative approach to delve into the perceptions of teachers regarding the CPD ITMS program within Rwanda's public secondary school. By employing this design, the study designed to uncover the perspectives, experiences, and insights of teachers involved in the program, offering a rich, detailed understanding of its impact and effectiveness. Through qualitative methods, the study sought to capture the depth and complexity of teachers' experiences with the CPD ITMS program, shedding light on the ways in which it has influenced their teaching practices, pedagogical approaches, and overall

professional development. This approach allowed for a comprehensive exploration of the program's strengths and limitations, providing valuable insights that informed future enhancements and improvements to ensure its continued relevance and efficacy in enhancing teaching quality in Rwanda's secondary schools.

Participants

Four teachers, participated in the research work, with a ratio of three women to one man, identified as T01-04. Their involvement unfolded within the confines of a carefully selected public secondary school in Rwanda. This particular school was chosen for its alignment with the teachers' prior exposure to Continuous Professional Development, ensuring a contextually relevant setting for the study. Within the research framework, four teachers, distinguished by the codes T01 through T04, engaged in the study's proceedings. Among them, the cohort comprised three female and one male teacher, representing a blend of perspectives and experiences. The investigation explained within the premises of a designated public secondary school in Rwanda, strategically chosen to accommodate the teachers' prior training in CPD ITMS. This deliberate selection aimed to raise an environment conducive to the exploration of pertinent educational phenomena.

The study enlisted the participation of four teachers, each designated with a unique identifier ranging from T01 to T04. This quartet consisted of three female teachers and one male counterpart, forming a balanced representation within the research cohort. Their collaborative involvement unfolded within the confines of a meticulously chosen public secondary school in Rwanda, distinguished by its alignment with the teachers' prior engagement in CPD ITMS. This strategic selection underscored the significance of contextual relevance in shaping the study's findings and implications.

Additionally, the study employed purposive sampling to select participants based on specific criteria such as prior involvement in the CPD ITMS program. This method ensured that the selected teachers had relevant experiences that aligned with the study's focus. The school was chosen for its past of CPD ITMS engagement, making it a representative context for understanding broader practices in other similar Rwandan public schools.

Instruments

Conducting interviews emerged as the cornerstone for data collection, allowing for an in-depth investigation of participants' perspectives and insights. Through the utilization of semi-structured questions and raising an atmosphere of open communication, these interviews became a catalyst for delving deep into the intricacies of teachers' encounters with CPD initiatives in the educational setting of Rwanda. The interactive nature of the interviews enabled a holistic understanding of teachers' attitudes and responses towards the integration of ITMS within their professional development journey. By adopting a semi-structured approach and encouraging open discussions, the interviews served as a powerful conduit for capturing the teachers' viewpoints and challenges. Through this methodological lens, a comprehensive comprehension of the multifaceted dimensions surrounding the implementation of ITMS within the context of professional development in Rwanda was achieved.

Employing interviews as the primary data-gathering tool paved the way for exploration of teachers' lived experiences and perspectives concerning CPD ITMS in Rwanda. By raising an environment conducive to open dialogue and utilizing semi-structured inquiries, these interviews provided a platform for teachers to articulate their insights and concerns comprehensively. Thus, illuminating the intricate dynamics at play within the realm of CPD initiatives, the interviews offered valuable insights into the effective integration of ITMS for enhancing professional development practices among Rwandan teachers.

Data Analysis

To analyze the data obtained from interviews, a thematic coding approach was employed. This method helped identify key themes and insights related to teachers' views on the CPD ITMS in Rwanda. By systematically categorizing the responses, researchers were able to extract meaningful patterns and perspectives from the interviews, shedding light on the effectiveness and impact of the CPD program. The thematic coding process enabled a comprehensive examination of the interview data regarding teachers' perceptions of the CPD ITMS in Rwanda. Through this method, researchers identified and interpreted the principal themes emerging from the interviews, providing valuable insights into how educators view the program's relevance, benefits, and challenges. By organizing the data thematically, researchers were able to highlight the most significant aspects of teachers' experiences with the CPD ITMS, contributing to a deeper understanding of its impact on professional development in mathematics and science education.

By employing thematic coding, researchers were able to uncover the underlying patterns and insights within the interview data, revealing perspectives on the CPD ITMS among teachers. This systematic approach facilitated a structured analysis of the data, allowing researchers to identify key themes and extract meaningful insights that offer valuable implications for the future development and implementation of professional development programs in the region.

Additionally, thematic coding involved systematically analyzing interview transcripts to identify key codes such as teaching strategies, program effectiveness, and challenges in implementation. From these codes, larger themes like impact on professional growth and barriers to effective integration were developed, providing a deeper understanding of teachers' experiences with the CPD ITMS program.

Trustfulness

Participants' responses underwent meticulous scrutiny, ensuring their accuracy and consistency. This was achieved by rigorously triangulating data from interview and corroborating findings through member checking. Through this thorough process, researchers confirmed the reliability of participants' contributions, supporting the credibility of the research outcomes. By triangulating data sources and conducting member checks, researchers validated the accuracy and consistency of their inputs. This rigorous verification process underscored the reliability of the findings, affirming the trustworthiness of the insights collected from participant interactions.

Ethical Considerations

Absolutely, maintaining the sanctity of participant consent, confidentiality, and transparency concerning data usage stands as an unyielding commitment, upholding the core tenets of informed consent and privacy (Stucke, 2023). Every interaction with data hinges upon a foundation of trust, ensuring participants' autonomy and rights were safeguarded at every turn. Through unwavering dedication, we cultivate an environment where individuals' contributions are valued, their identities shielded, and their trust unequivocally honored. At the heart of the operations lies an unwavering dedication to upholding the principles of informed consent and privacy. Researchers recognized that participant consent was not just a checkbox; it's a fundamental acknowledgment of individual autonomy and agency. By prioritizing transparency in data usage and safeguarding confidentiality, in doing so, participant consent, confidentiality, and transparency regarding data usage to honor the principles of informed consent and privacy respected.

Additionally, participants were informed of the study's purpose and voluntarily provided written consent before interviews. Their participation process included one-on-one interviews, and data confidentiality was strictly maintained by anonymizing responses and storing data securely, accessible only to the study team.

RESULTS AND DISCUSSION

This study delved into the perceptions of mathematics and science teachers regarding the CPD ITMS in public secondary school in Rwanda. Four purposively selected teachers participated in the interviews, providing rich insights into their experiences and perspectives on the program. The results and ensuing discussion are structured around several key themes that emerged from the data analysis.

Theme 1: Perceived Benefits of CPD ITMS

All interviewed teachers expressed positive perceptions regarding the benefits of CPD ITMS. They highlighted how the program equipped them with innovative teaching strategies improved to the specific context of mathematics and science education in Rwanda. Teachers reported an enhanced ability to engage students actively in the learning process, raising deeper understanding and critical thinking skills. Moreover, CPD ITMS was seen as instrumental in improving teachers' confidence in their pedagogical approaches and content knowledge, ultimately leading to more effective teaching practices. One teacher highlighted,

CPD ITMS offers an enhanced ability to engage students actively in the learning process, raising deeper understanding and honing critical thinking skills (T03).

All interviewed teachers expressed positive perceptions of CPD ITMS, noting that, despite these constraints, the program empowered them with innovative strategies tailored to mathematics and science education in Rwanda. This connection between resource challenges and the effectiveness of CPD ITMS illustrates how overcoming such barriers can enhance teachers' confidence and

their ability to actively engage students, fostering deeper understanding and critical thinking skills.

Theme 2: Challenges and Limitations

Despite the overall positive reception, teachers also identified several challenges associated with CPD ITMS. One common concern was the time constraints imposed by the program, particularly for teachers already burdened with heavy workloads. Additionally, some teachers expressed anticipation with the lack of follow-up support or opportunities for further collaboration and reflection after completing the program. Furthermore, logistical issues such as access to resources and technology posed additional hurdles for effective implementation. One teacher emphasized,

CPD ITMS is beneficial, providing opportunities for growth and skill enhancement. However, the time constraints imposed by the program, especially for teachers who already have heavy workloads (T01).

Theme 3: Impact on Student Learning

Teachers consistently acknowledged the positive impact of CPD ITMS on student learning outcomes. They observed increased student engagement, motivation, and performance in mathematics and science subjects. Moreover, teachers noted a shift in students' attitudes towards these subjects, with greater enthusiasm and interest sparked by the innovative teaching methods learned through the program. These findings underscored the crucial link between teacher professional development and student achievement in STEM education. One teacher underlined,

The impact of CPD ITMS on student engagement, motivation, and performance in mathematics and science subjects cannot be overstated. Its integration has sparked a noticeable shift in classroom dynamics, with students exhibiting heightened interest and participation, leading to tangible improvements in their academic outcomes (T04).

Theme 4: Professional Growth and Development

Participation in CPD ITMS was viewed as a catalyst for professional growth and development among teachers. They described how the program provided opportunities for self-reflection, experimentation, and continuous improvement in their teaching practices. Moreover, CPD ITMS encouraged teachers to stay abreast of emerging trends and best practices in mathematics and science education, fostering a culture of lifelong learning within the profession. This theme highlights the transformative potential of targeted professional development initiatives in enhancing teacher effectiveness and job satisfaction. One teacher highlighted,

CPD ITMS was truly transformative for teachers, serving as a catalyst for their professional growth and development (T01).

Theme 5: Impacts of the Program on their Student Outcomes

In the analysis of interviews conducted with four secondary school teachers who participated in CPD ITMS in Rwanda, several keys emerged regarding the perceived impacts of the program on their professional practices and student outcomes. One prominent item was the enhancement of pedagogical strategies. Teachers reported a marked improvement in their instructional approaches, particularly in integrating technology and interactive methodologies into their lessons. This was seen to improve greater engagement and understanding among students, as evidenced by increased class participation and interest for mathematics and science subjects. Teachers also noted that the program enabled them to design more effective lesson plans that cater to diverse student needs, which they believed contributed to improved academic performance in these subjects. One teacher highlighted,

The CPD ITMS program has been transformative in how I approach lesson planning. It provided me with the tools to create more personalized and effective lesson plans, improved specifically to the various needs of my students. This customization has been a game changer, and I have observed a noticeable improvement in their academic performance (T03).

Theme 6: Confidence among Teachers

A significant result revolved around the increased confidence among teachers. Participants expressed that the CPD ITMS had equipped them with not only advanced content knowledge but also with the confidence to experiment with new teaching methods and tools. This newfound confidence was reported to translate into more dynamic and responsive classroom environments. They also observed an increase in students' confidence, attributing this to the teachers' enhanced ability to clarify complex topics and create a more supportive learning atmosphere. One teacher emphasized,

Students are more engaged and participative, responding excitedly to the dynamic atmosphere. It's evident that teachers' enhanced clarity and support have empowered students, raising a sense of self-assurance that positively impacts their learning journey (T04).

Theme 7: Collaborative and Reflective Teaching Practice

Furthermore, the interviews highlighted a shift towards a more collaborative and reflective teaching practice as a result of the CPD ITMS program. Teachers shared experiences of increased collaboration among their peers, noting that the program raised a sense of community and shared purpose that extended beyond the individual classrooms. This collaboration often took the form of sharing resources and teaching strategies, which contributed to a more cohesive educational approach within their schools. Additionally, teachers emphasized a deeper commitment to reflective practice, routinely assessing their teaching methods and student responses to adapt and optimize learning outcomes. This underscores a broader impact of the CPD ITMS program, suggesting that it not only enhances individual teacher performance but also promotes a more reflective and collaborative educational culture within schools. One teacher underscored,

My interactions with colleagues have truly evolved since implementing this program. There is a tangible sense of friendship and unity among us. Through shared resources and teaching strategies, we have unlocked new levels of collaboration, enriching the educational experience for our students. This collaborative spirit has raised a dynamic learning environment where innovation thrives and every voice is valued (T01).

Theme 8: Institutional Support and Policy Implications

The role of institutional support emerged as a critical factor influencing the success of CPD ITMS. Teachers emphasized the importance of ongoing support from school administrators and education authorities in facilitating program implementation and sustaining momentum beyond initial training sessions. Moreover, there were calls for policy reforms aimed at integrating innovative teaching practices into the broader educational framework and incentivizing participation in professional development initiatives. One teacher highlighted,

It is imperative that school administrators and education authorities recognize the pivotal role they play in supporting the implementation and durability of programs within educational settings (T02).

Therefore, the findings of this study shed light on the perceptions of mathematics and science teachers regarding the CPD ITMS in Public Secondary Schools in Rwanda. While teachers overpoweringly recognized the benefits of the program in enhancing their pedagogical skills and student outcomes, they also identified challenges related to time constraints, resource limitations, and the need for ongoing support. Moving forward, it is essential to address these challenges and capitalize on the momentum generated by CPD ITMS to raise the values of continuous improvement and innovation in mathematics and science education in Rwanda.

The PDS model's emphasis on ongoing, collaborative learning among teachers aligns closely with the current study's results. The CPD ITMS programs likely raised a similar environment of continuous learning and collaboration, directing to improve instructional practices and ultimately enhance student achievement in mathematics and science. Both the PDS model and the CPD ITMS program highlighted the importance of teachers' professional growth and its direct impact on student outcomes, suggesting a shared goal of advancing teaching quality through structured, collaborative professional development.

The present research findings are in line with the conclusions drawn by Fraser et al. (2007), indicating that teachers consistently view CPD as crucial for their professional advancement, facilitating their ability to remain abreast of contemporary educational methodologies, technological advancements, and alterations in curriculum. Additionally, these results align with the assertions made by Sum et al. (2018), emphasizing the overarching significance of CPD within the educational domain, notably in the realms of mathematics and science instruction. Their study underscores the favorable effects of CPD initiatives on educators' instructional techniques, subject matter expertise, and ultimately, student achievement outcomes. The study's outcomes resonate with Nunguye et

al. (2022), underscoring the imperative for teachers to engage in continuous learning to navigate the ever-evolving landscape of educational methodologies. Moreover, the findings also echo the sentiments put forth by Abakah et al. (2022), shedding light on the significance and efficacy of CPD programs in refining teaching methodologies and fostering positive student learning outcomes. As teachers participate in CPD initiatives, they gained access to updated pedagogical techniques and valuable insights, which in turn enrich their teaching practices and contribute to enhanced student academic performance. Furthermore, the present findings align with Niyibizi and Mutarutinya (2024), who indicated that implementing innovative assessment methods, such as formative assessments and project-based learning, coupled with a timely feedback approach, significantly enhances students' comprehension, engagement, and overall performance. Teachers, as facilitators of this process, play a crucial role in creating a supportive learning environment.

CONCLUSION

The study highlighted the positive impact of the CPD ITMS on both teachers' pedagogical skills and student outcomes in Rwandan public secondary schools. However, it also underscored the importance of addressing challenges such as time constraints and resource limitations to fully capitalize on the program's potential. The research findings to the identified challenges revealed that overcoming these barriers is crucial for the continued development of mathematics and science education in Rwanda. Moreover, the recommendations provided in the conclusion present that stakeholders enhance the effectiveness of the CPD ITMS program, particularly in the context of Rwandan public secondary schools. Moving forward, there is a need for sustained school support and policy reforms to promote a culture of continuous improvement and innovation in STEM education. Finally, suggestions for further research should focus on exploring related issues not addressed by this study, thereby contributing to a more comprehensive understanding of the factors influencing STEM education in Rwanda.

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