



# Examining the Contribution of Continuous Professional Development on Students' Academic Performance in Mathematics in Rwanda Secondary Schools

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**Abstract:** *This study investigated the contribution of Continuous Professional Development (CPD) to students' academic performance in mathematics in selected secondary schools in Rwanda. Recognizing the pivotal role of teacher quality in student learning, the research aimed to evaluate how CPD influences instructional practices, examine the relationship between CPD participation and student achievement, and identify challenges teachers face in applying CPD knowledge. A mixed-methods approach was employed, involving questionnaires, interviews, classroom observations, and analysis of student assessment data from 305 learners and 36 mathematics teachers. Quantitative analysis revealed that students taught by teachers who had completed at least 35 hours of CPD scored significantly higher than those taught by teachers with fewer training hours. ANOVA results showed a statistically significant difference ( $F(2, 33) = 5.94, p < 0.01$ ) among CPD exposure groups, and Pearson's correlation ( $r = 0.46, p < 0.01$ ) indicated a moderate positive relationship between CPD and student performance. Qualitative findings supported these results, showing improvements in learner-centered instruction, assessment use, and curriculum alignment. However, challenges such as limited resources, time constraints, overcrowded classrooms, and insufficient mentorship hindered effective implementation. The study concludes that while CPD has a positive impact on teaching practices and learning outcomes, its success depends on consistent delivery, subject relevance, and institutional support. It recommends policy reforms to ensure sustained and equitable CPD access, along with practical strategies to enhance classroom implementation and teacher support systems.*

**Keywords:** *Continuous professional development, Instructional practices, Mathematics performance, Secondary schools, Student achievement*

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## 1. Introduction

Continuous Professional Development (CPD) has gained increasing recognition worldwide as a critical factor in improving teacher quality and, subsequently, student

learning outcomes. Globally, education systems have emphasized the importance of equipping teachers with up-to-date pedagogical content knowledge and adaptive teaching strategies to meet the evolving demands of 21st-century education. In countries such as Finland, Singapore, and the United Kingdom, CPD is institutionalized and

strongly linked to student achievement, particularly in core subjects like mathematics (Darling-Hammond et al., 2017). Research demonstrates that when teachers participate in well-designed professional development that is ongoing, collaborative, and content-specific, there is a significant improvement in students' academic performance (OECD, 2016). Mathematics, a subject central to scientific and technological advancement, often serves as a key indicator for evaluating the effectiveness of teaching practices and policy interventions.

In the African context, many education systems have begun to prioritize teacher professional development to address longstanding challenges in student achievement, especially in mathematics. Sub-Saharan African countries such as Kenya, Ghana, and South Africa have launched national CPD frameworks aiming to enhance teacher competencies through structured training, mentoring, and peer collaboration (UNESCO, 2019). For example, South Africa's Integrated Strategic Planning Framework for Teacher Education and Development (ISPFTED) outlines targeted professional development initiatives for improving mathematics teaching. However, despite these efforts, student performance in mathematics continues to lag behind global averages. A 2020 report by the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) indicates that students in many African countries perform below proficiency levels in mathematics, often due to inadequacies in instructional delivery and insufficient teacher preparation. This suggests that CPD programs, while present, are inconsistently implemented or misaligned with classroom realities.

In Rwanda, the need for effective CPD is particularly pressing within the framework of the Competence-Based Curriculum (CBC) introduced in 2015. This curriculum reform requires a shift from teacher-centered to learner-centered methodologies, promoting critical thinking, problem-solving, and real-life application of knowledge skills that are especially vital in mathematics education (REB, 2015). To support this pedagogical transformation, the Rwanda Education Board (REB) and the Ministry of Education have developed CPD programs through platforms such as the Teacher Training Colleges (TTCs), In-Service Education and Training (INSET), and School-Based Mentorship (SBM). These initiatives aim to enhance teachers' competencies in lesson planning, use of teaching aids, assessment strategies, and learner engagement.

Despite these efforts, national assessments and studies continue to reveal challenges in mathematics achievement among Rwandan students. The 2022 National Examinations Results indicated that performance in mathematics, particularly at the lower secondary level, remains relatively weak compared to other subjects (REB, 2022). Various studies have attributed this gap to

inconsistencies in teachers' mastery of content and methodology, limited access to CPD resources, and poor follow-up mechanisms (Mugiraneza, 2021; Uwizeyimana & Yadeta, 2023). Furthermore, CPD opportunities in rural schools are often less frequent and of lower quality than in urban areas, exacerbating the disparity in educational outcomes.

Several empirical studies have examined the link between CPD and academic performance in different contexts. For instance, Yoon et al. (2007) found that students performed better in mathematics when their teachers participated in CPD programs lasting more than 30 hours per year. In Rwanda, Ntirenganya (2020) found a positive correlation between CPD participation and teachers' ability to implement learner-centered strategies in mathematics classrooms, though the study called for more rigorous evaluation of CPD quality and sustainability. This growing body of evidence underscores the potential of CPD to impact student outcomes but also highlights the necessity of contextualized and consistent implementation.

Given this backdrop, the present study seeks to examine the contribution of Continuous Professional Development on students' academic performance in mathematics in Rwandan secondary schools. By focusing on the Rwandan context while drawing insights from global and African experiences, this study aims to identify the effectiveness, challenges, and opportunities associated with CPD in fostering improved mathematics learning outcomes. It is hoped that the findings will inform future policy and practice, ensuring that CPD initiatives translate into tangible academic gains, especially within the national goals of achieving quality and inclusive education for all.

## 1.1 Statement of Research Problem and Motivation

Around the world, there is growing recognition that quality teaching is a decisive factor in improving student learning outcomes, particularly in mathematics—a subject often considered a gateway to scientific, technological, and economic advancement. Research from developed countries such as the United States, Finland, and Singapore shows a strong correlation between effective Continuous Professional Development (CPD) for teachers and improved student academic performance (Darling-Hammond et al., 2017; OECD, 2016). These countries have institutionalized CPD as a long-term, systematic, and reflective process embedded in the teaching profession. However, despite its demonstrated benefits, CPD remains inconsistently implemented and evaluated in many parts of the world, especially in low-income settings.

In Africa, educational systems face persistent challenges in improving mathematics performance, partly due to insufficient investment in teacher professional growth. While countries like Kenya, Ghana, and South Africa have launched CPD frameworks to enhance teacher content knowledge and pedagogy, the impact on student outcomes remains mixed (UNESCO, 2019). Many CPD programs are criticized for being sporadic, overly theoretical, or disconnected from classroom realities. Moreover, limited monitoring, resource constraints, and lack of teacher motivation hinder the effectiveness of these initiatives. Studies such as those by SACMEQ and TIMSS have repeatedly shown low mathematics achievement across sub-Saharan Africa, pointing to gaps in teaching quality as a major contributing factor.

In Rwanda, the education sector has undergone substantial reforms, notably the introduction of the Competence-Based Curriculum (CBC) in 2015. This curriculum mandates a shift from rote learning to student-centered, skills-based education, particularly in mathematics, which requires teachers to adopt new instructional approaches (REB, 2015). To support this transition, the government and development partners have launched several CPD initiatives, including school-based mentorship, peer learning communities, and in-service training. However, despite these efforts, national examination reports and independent studies consistently reveal low performance in mathematics, especially in lower secondary schools (REB, 2022; Mugiraneza, 2021).

The discrepancy between policy and practice suggests a pressing need to assess the effectiveness of CPD in influencing student academic achievement in mathematics. Existing studies in Rwanda have focused largely on teacher satisfaction, training coverage, or general pedagogical changes, with limited empirical evidence linking CPD directly to student performance outcomes. Furthermore, little attention has been paid to contextual factors such as the availability of trained mentors, school leadership support, and urban-rural disparities in CPD access and quality. This represents a significant gap in both research and practice.

This study is therefore motivated by the need to fill these knowledge gaps and provide empirical evidence on how CPD contributes to students' academic performance in mathematics within the Rwandan secondary school context. Understanding this relationship is vital for guiding national policy, optimizing resource allocation, and ensuring that teacher development initiatives have meaningful, measurable impacts on student learning. By examining the effectiveness of CPD from both teacher and student perspectives, the study aims to inform sustainable, data-driven strategies for improving mathematics education in Rwanda and comparable settings.

## 1.2 Objectives of the Study

### 1.2.1 General Objective

The primary aim of this study is to examine the contribution of Continuous Professional Development (CPD) programs on students' academic performance in mathematics in Rwanda's secondary schools.

### 1.2.2 Specific Objectives

1. To evaluate how Continuous Professional Development (CPD) influences mathematics teachers' instructional practices and pedagogical competence.
2. To investigate the relationship between teachers' participation in CPD and students' performance in mathematics.
3. To identify challenges faced by teachers in accessing and implementing knowledge gained from CPD in the teaching of mathematics.

## 1.3 Research Questions

1. In what ways does participation in Continuous Professional Development (CPD) influence mathematics teachers' instructional practices and pedagogical competence?
2. What is the relationship between teachers' involvement in CPD and students' academic performance in mathematics?
3. What challenges do mathematics teachers face in accessing or applying CPD knowledge in classroom instruction?

## 2. Literature Review

The literature review addresses the theoretical underpinnings and empirical evidence related to Continuous Professional Development (CPD) and its role in improving students' academic performance, particularly in mathematics. The review is structured in two main parts: theoretical literature, which explores relevant frameworks guiding the understanding of CPD, and empirical literature, which synthesizes findings from global, regional, and local contexts. This structured approach helps to identify research gaps and situate the current study within broader academic discourse.

### 2.1 Theoretical Literature Review

#### 2.1.1. Adult Learning Theory

One of the foundational theories supporting CPD initiatives is Adult Learning Theory, also known as Andragogy, developed by Malcolm Knowles (1980). This theory asserts that adults learn best when the learning is self-directed, problem-centered, and relevant to their immediate professional needs. In the context of CPD, this means that mathematics teachers benefit most when professional development is participatory, contextual, and linked to real classroom challenges. Teachers are not passive recipients but active agents who draw upon their experience to construct new understandings.

In Rwanda, CPD often takes the form of workshops and short-term seminars, yet research suggests these formats may not fully embrace the principles of adult learning. The theory urges CPD planners to design training that fosters critical reflection, collaboration, and hands-on activities. For mathematics education, this includes engaging teachers in lesson study, peer observations, and collaborative problem-solving aligned with the Competence-Based Curriculum (CBC).

### 2.1.2 Guskey's Model of Teacher Change

Another guiding framework is Guskey's Model of Teacher Change (2002), which posits that professional development must lead to improved student outcomes to be meaningful and sustained. According to this model, change in teacher beliefs and practices occurs after they observe positive results in student learning. Therefore, CPD should not only aim to improve teacher knowledge but must also be evaluated based on student performance metrics.

In practice, Guskey's model advocates for a cyclical relationship between teacher learning and student achievement. In the Rwandan context, this model suggests that CPD programs for mathematics teachers should be designed with built-in mechanisms to assess whether student learning has improved thus validating the effectiveness of the CPD.

### 2.1.3 Constructivist Learning Theory

Continuous Professional Development (CPD) is also supported by Constructivist Learning Theory, whose major proponents include Jean Piaget and Lev Vygotsky. Constructivist Learning Theory holds that learners actively construct knowledge through their experiences, social interactions, and reflection. This theoretical perspective aligns with the Competence-Based Curriculum (CBC), which emphasizes learner-centered pedagogy, active participation, problem-solving, and collaborative inquiry. For teachers to effectively implement these constructivist-oriented strategies in mathematics classrooms, CPD should itself model constructivist practices by moving beyond traditional lecture-based approaches to interactive,

collaborative, and learner-centered instructional techniques.

## 2.2 Empirical Literature Review

### 2.2.1 Global Perspectives on CPD and Mathematics Achievement

Numerous global studies have emphasized CPD as a vital mechanism for improving both teacher effectiveness and student outcomes. According to Darling-Hammond et al. (2017), high-quality CPD is continuous, content-focused, and aligned with curriculum goals. In countries such as Finland, Singapore, and the United Kingdom, CPD is institutionalized and regarded as an integral component of teacher professionalism. These countries have witnessed consistent improvement in students' performance in mathematics due to well-designed CPD systems that emphasize coaching, collaborative planning, and classroom-based research.

Yoon et al. (2007) found that when teachers received more than 30 hours of sustained CPD annually, student performance in mathematics improved significantly. The OECD (2016) also reported that mathematics teachers involved in continuous training were more confident and employed more active learning strategies.

However, most of these studies were conducted in high-income countries with robust education systems and extensive CPD resources. The scalability and effectiveness of such models in low-resource settings like Rwanda are yet to be empirically verified. Therefore, a critical gap remains regarding the applicability and adaptation of global CPD models to the Rwandan educational context.

### 2.2.2 CPD and Mathematics Instruction in Africa

In sub-Saharan Africa, efforts have been made to integrate CPD into education systems. Countries such as Kenya, Ghana, and South Africa have implemented national frameworks designed to support teacher development. South Africa's Integrated Strategic Planning Framework for Teacher Education and Development, for instance, promotes in-service training with a focus on mathematics and science subjects.

Empirical studies from the region affirm the potential of CPD to improve instructional practices. For instance, Owan and Agunwamba (2020) in Nigeria found that teachers who received subject-specific CPD reported improved confidence and used more effective instructional strategies. Similarly, in Ghana, structured CPD programs led to greater use of interactive teaching methods and improved student engagement in mathematics.

Nevertheless, many African CPD programs are criticized for being top-down, infrequent, and disconnected from classroom realities (Wadesango, 2012). Teachers often lack ongoing mentorship and follow-up after workshops. Furthermore, the link between CPD and actual student academic performance is rarely assessed, and data on long-term impact remain sparse.

### **2.2.3 The Rwandan Context: Reforms, CPD, and CBC Implementation**

In recent years, Rwanda has placed increasing emphasis on Continuous Professional Development (CPD) as a vehicle for improving educational quality, particularly within the framework of the Competence-Based Curriculum (CBC) introduced in 2015. The CBC mandates a shift from traditional, teacher-centered pedagogy to learner-centered, skill-based instruction aimed at fostering critical thinking, problem-solving, and collaboration especially within mathematics, a subject critical for national development. To support this shift, various CPD models have been introduced, including In-Service Education and Training (INSET), School-Based Mentorship (SBM), and online platforms facilitated by Teacher Training Colleges (TTCs) and the Rwanda Education Board (REB).

Several empirical studies in Rwanda offer valuable insights into the implementation and perceived impact of CPD on teacher practices. For instance, Mugaranza (2021) found that CPD programs had improved teachers' awareness and theoretical understanding of learner-centered methodologies. However, the study also noted that many teachers lacked the capacity to implement these strategies effectively due to limited access to instructional resources, time constraints, and the absence of regular follow-up or mentorship. Similarly, research by Uwizeyimana and Yadeta (2023) highlighted disparities in CPD participation between rural and urban schools, with teachers in remote areas reporting fewer opportunities and lower-quality training experiences.

In another study, Ntirenganya (2020) identified a positive relationship between teacher participation in CPD and the use of active learning strategies in mathematics instruction. Teachers who had undergone CPD were more likely to incorporate group work, real-life examples, and formative assessments in their teaching. Despite this progress, the study acknowledged that the connection between CPD and student academic performance remained tenuous, primarily because student outcomes were not tracked longitudinally. Furthermore, the CPD programs lacked subject specificity, and many mathematics teachers expressed a need for more targeted content related to mathematical reasoning, assessment design, and differentiated instruction.

Despite these findings, national assessment reports continue to show that mathematics performance among secondary school students in Rwanda remains relatively low. According to the Rwanda Education Board (REB, 2022), mathematics was among the least performed subjects in national examinations at the lower secondary level. This persistent underachievement raises critical questions about the effectiveness of CPD programs in translating pedagogical improvement into measurable academic gains for students. It also underscores the need to move beyond teacher self-reports and instructional practices and to empirically examine how CPD contributes to student learning outcomes.

A notable gap in the current body of research is the absence of comprehensive, outcome-oriented evaluations of CPD effectiveness. Most studies in Rwanda focus on teacher perceptions, satisfaction, or changes in teaching methods, while relatively few assess the direct impact of CPD on student achievement in mathematics. Moreover, there is limited research exploring the role of contextual factors such as school leadership support, availability of mentors, resource constraints, and classroom conditions in mediating the effectiveness of CPD. For instance, while school-based mentorship is promoted by REB as a cornerstone of ongoing professional development, little empirical work has assessed how mentorship quality or frequency influences student learning in mathematics classrooms.

Another underexplored area is the role of CPD in supporting inclusive education practices within mathematics instruction. With increasing policy emphasis on inclusive education, there is a growing need to investigate whether CPD equips teachers with strategies to support learners with diverse needs, including those with disabilities or those from disadvantaged socio-economic backgrounds. Current CPD programs often lack modules on inclusive pedagogy, assessment accommodations, or differentiated teaching in mathematics, which may further marginalize vulnerable student populations.

Furthermore, CPD delivery mechanisms in Rwanda often rely on one-off workshops and seminars, which research suggests are insufficient for sustained teacher learning and practice change. Studies have not adequately explored alternative or complementary CPD models such as lesson study, peer coaching, action research, or blended learning approaches that combine face-to-face and online components. These methods have shown promise in other contexts but remain underutilized in Rwanda, partly due to logistical challenges and limited research evidence supporting their efficacy in local settings.

There is also a lack of disaggregated data on the differential impact of CPD across teacher demographics. For instance, how does CPD effectiveness vary by years of teaching

experience, academic qualifications, or gender? Does CPD impact novice and veteran mathematics teachers differently? Answering such questions is vital for designing differentiated professional development strategies that meet teachers at their level of need and expertise.

Finally, student voices are largely missing in current research on CPD in Rwanda. Most studies rely on teacher and administrator perspectives, ignoring how students perceive changes in instructional practices and classroom engagement. Including student insights could offer valuable evidence on whether CPD is making a tangible difference in their learning experiences and performance in mathematics.

### **2.3 Utility and Contribution of this Literature Review**

This literature review has critically synthesized global, regional, and national scholarship on CPD and its relationship with student performance in mathematics. It has highlighted several key insights: CPD is globally recognized as a vehicle for improving teaching quality and student outcomes, particularly in mathematics. In African countries, CPD programs are often present but weakly aligned to classroom realities, with minimal impact evaluation and in Rwanda, although CPD is supported by national policy, its implementation suffers from fragmentation, lack of subject focus, and unclear links to student achievement.

By revealing these patterns, the literature review justifies the need for the proposed study. It identifies a critical research gap—the lack of empirical evidence connecting CPD to actual mathematics performance outcomes in the Rwandan context. Additionally, it underscores the importance of tailoring CPD to specific teaching challenges in mathematics and tracking its effectiveness beyond teacher perceptions.

## **3. Methodology**

This section outlines the research methodology employed to examine the contribution of Continuous Professional Development (CPD) to students' academic performance in mathematics in Rwanda's secondary schools. It provides a detailed description of the research paradigm, approach, context of the study, target population, sampling techniques, data collection instruments, and data analysis methods. These methodological choices are justified based on their suitability to address the study's objectives and answer the research questions effectively. By adopting a systematic and coherent methodological framework, the study ensures that the evidence collected is both reliable

and valid for drawing meaningful conclusions and recommendations.

### **3.1 Research Paradigm**

This study is guided by the pragmatic research paradigm. Pragmatism supports the integration of both qualitative and quantitative approaches to explore complex educational issues. In the context of this research, pragmatism allows the researcher to explore both the statistical relationships between CPD and student academic performance and the qualitative experiences of teachers and education stakeholders. The paradigm acknowledges that educational realities are multi-faceted and best understood through diverse data sources. As CPD involves human interaction, institutional contexts, and cognitive changes, pragmatism offers the flexibility to balance objectivity with personal and contextual understanding. The paradigm further supports the convergence of data to develop a comprehensive view of the problem under investigation.

### **3.2 Research Approach**

The study adopts a mixed-methods approach, specifically a convergent parallel design. This design entails collecting both qualitative and quantitative data concurrently, analyzing them independently, and integrating the results during interpretation. The rationale behind this approach is that neither quantitative nor qualitative methods alone are sufficient to capture the complexity of CPD's impact on students' mathematics performance. Quantitative methods will allow for statistical measurement and generalization of findings across the selected sample, while qualitative methods will provide in-depth understanding of the processes, challenges, and perceptions underlying CPD implementation. This approach ensures complementarity of findings and strengthens the validity of the research conclusions.

### **3.3 Location and Context of the Study**

The study was conducted in selected districts of Rwanda's Eastern Province, specifically in Bugesera, Kayonza, and Ngoma. These districts were purposively selected to represent a blend of rural and semi-urban school settings, reflecting the diversity of CPD implementation in the Rwandan education system. Rwanda's education sector has undergone significant transformation since the introduction of the Competence-Based Curriculum (CBC) in 2015, which emphasized student-centered learning and problem-solving. While the Rwanda Education Board (REB) has introduced CPD initiatives to support this transition, student performance in mathematics remains relatively low at the national level. This context provides a relevant and timely setting for examining how CPD affects

mathematics instruction and learning outcomes in lower secondary schools.

### **3.4 Population of the Study**

The study targets key stakeholders involved in the implementation and impact of CPD in mathematics education. These include mathematics teachers in lower secondary schools, students in Senior One to Senior Three, head teachers, school-based mentors and sector education inspectors. Mathematics teachers form the core of the population as direct beneficiaries and implementers of CPD. Students are included to assess the outcome variable academic performance while school leaders and REB officials offer insights into CPD design, implementation, and systemic support. The inclusion of diverse participants ensures that the study captures multiple perspectives relevant to understanding CPD's effectiveness.

### **3.5 Sampling and Sample Size**

A multi-stage sampling strategy was used to select participants. First, purposive sampling was applied to select schools and districts with a documented record of CPD activities. These include schools that regularly participate in REB-led training programs, mentorship sessions, or continuous school-based CPD. Within selected schools, stratified sampling was employed to include mathematics teachers of different genders, levels of experience, and teaching environments (urban vs. rural). Students were randomly selected from classes taught by the sampled teachers to minimize bias. Additionally, purposive sampling was used again to select school leaders, mentors, and education officials based on their roles in CPD implementation. The sample will comprise approximately 18 schools, 36 mathematics teachers, 305 students and 12 school leaders or mentors. This diverse yet manageable sample size is considered adequate for statistical analysis and thematic saturation in qualitative data.

### **3.6 Data Collection Methods**

To answer the research questions comprehensively, the study employed a combination of data collection tools. First, structured questionnaires were administered to mathematics teachers. These included Likert-scale items to quantify CPD participation, perceived impact, and instructional changes, along with a few open-ended items to collect additional insights. Second, document analysis was conducted to examine CPD attendance logs, teacher performance reports, and student mathematics scores from termly and national examinations. These documents provided secondary data necessary for assessing the link between CPD and student performance. Third, semi-structured interviews were carried out with school leaders,

mathematics teachers and school mentors to explore CPD program design, implementation practices, and systemic challenges. Fourth, focus group discussions (FGDs) was conducted with selected students to understand their classroom experiences and perceptions of their teachers' instructional practices. Finally, classroom observations were conducted using a standardized checklist to document real-time teaching methods, student engagement, and use of CBC-aligned practices. The use of multiple instruments facilitates data triangulation, enhanced the study's credibility and depth.

### **3.7 Validity and Reliability**

To ensure the validity of the instruments and results, all tools will undergo expert review by education specialists at the University of Rwanda and was piloted in two non-sampled schools. Feedback from the pilot study was used to refine ambiguous items and improve clarity. Content validity was assessed by aligning the questionnaire and interview items with the study objectives and conceptual framework. Reliability was ensured through consistent administration of instruments, test-retest reliability checks on the teacher questionnaire, and the use of the same observation checklist across classrooms. For qualitative data, reliability was reinforced through peer debriefing, triangulation of sources, and member checking during interviews and FGDs.

### **3.8 Data Analysis Methods**

The analysis of quantitative data was conducted using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including frequencies, means, and standard deviations, was used to summarize teacher responses and CPD characteristics. Inferential statistics such as correlation and regression analyses was employed to examine the strength and direction of the relationship between CPD participation and student performance in mathematics. Differences in performance across gender, school location, and teacher experience was analyzed using t-tests and ANOVA.

Qualitative data from interviews, FGDs, and classroom observations were analyzed thematically. After transcription and translation (where necessary), data was coded manually. Codes were grouped into categories and themes that align with the study's objectives. Thematic analysis will help reveal underlying patterns in teacher experiences, implementation barriers, and observed changes in pedagogy. Integration of qualitative and quantitative findings will occur during interpretation, offering a richer, multidimensional understanding of the results.

### 3.9 Ethical Considerations

Ethical integrity was maintained throughout the research process. Prior to data collection, ethical approval was obtained from the University of Rwanda’s Institutional Review Board and relevant district education offices. Informed consent was sought from all adult participants, and assent was obtained from students along with parental consent. Participants were informed of the purpose of the study, their rights to confidentiality, voluntary participation, and the option to withdraw at any time. All data were anonymized, securely stored, and used strictly for academic purposes.

### 3.10 Limitations and Delimitations

This study acknowledges several limitations. First, establishing a direct causal link between CPD and student performance may be difficult due to the influence of other variables, such as school leadership and student motivation. Second, self-reported data from teachers may be subject to bias. Third, the study’s focus on selected

districts limits generalizability to all Rwandan secondary schools.

However, the study’s scope was clearly delimited. It focused specifically on lower secondary mathematics education in public and government-aided schools in the Eastern Province. Only formal CPD programs supported by REB or the Ministry of Education are considered. These boundaries help maintain focus while allowing for detailed analysis within a manageable context.

## 4. Results and Discussion

### 4.1 Influence of CPD on Instructional Practices and Teacher Competence

To assess how CPD affects instructional practices, data were collected through structured teacher questionnaires, interviews, and classroom observations. Table 1 summarizes teachers’ responses regarding changes in instructional behavior after participating in CPD programs.

Table.1: Teachers’ Perceived Impact of CPD on Instructional Practice (n = 36)

Instructional Practice Improved Through CPD	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Mean(1-5)
Improved understanding of the Competence-Based Curriculum	55.6	30.6	11.1	2.8	4.33
Use of learner-centered teaching strategies	52.8	25	19.4	2.8	4.28
Use of continuous assessments and feedback	44.4	27.8	25	2.8	4.14
Differentiation of instruction for mixed-ability learners	41.7	30.6	25	2.7	4.11

Table.1 shows teacher perceptions about how CPD affected their instructional practices. The high percentage of teachers who agreed or strongly agreed with each statement (over 80% for all items) confirms that CPD has greatly improved their teaching. The top-rated item was “Improved understanding of the Competence-Based Curriculum” (mean score = 4.33), followed by “Use of learner-centered teaching strategies” (mean score = 4.28). This indicates that CPD has been especially effective in helping teachers adjust their teaching to fit the national curriculum and use interactive strategies. Additionally, the ratings for “Use of continuous assessments and feedback” (mean = 4.14) and “Differentiation of instruction” (mean =

4.11) suggest that teachers have also enhanced their ability to monitor student learning and modify teaching to address different needs. This supports Germuth (2018) idea that teacher professional development should focus on changing classroom practices to have a lasting effect. These findings meet the first objective by showing that CPD directly strengthens teaching skills and the ability to apply CBC principles.

## 4.2 Relationship Between CPD and Student Mathematics Performance

The second objective of the study was to examine whether participation in CPD influences student academic outcomes in mathematics. To explore this, third-term mathematics marks from 305 students were analyzed and compared across teacher CPD exposure levels.

Table. 2: Descriptive Statistics of Student Mathematics Performance (n = 305)

Statistic	Score (%)
Mean	60.1
Median	64
Standard deviation	18.9
Minimum	1
Maximum	97

Table .2 shows the general performance of the 305 students in the study. The average score was 60.1%, which means that, overall, students performed at a moderate level. However, the wide range of scores, from 1% to 97%, along with a standard deviation of 18.9, indicates significant differences in achievement across various classrooms and schools. This variation is important because it allows us to

look at the factors that contribute to it, especially the role of teacher continuing professional development (CPD). Since the average score is above 50%, it shows that many students are meeting the expected learning outcomes. Yet, the large spread suggests that not all students are benefiting equally. These differences set the stage for further analysis in Tables.3 and .4.

Performance Band	Frequency	Percentage (%)
<30 (Severe risk)	33	10.8
30–49 (Basic)	31	10.2
50–69 (Proficient)	133	43.6
≥70 (Advanced)	108	35.4

Table.3 breaks down student performance into four categories: Severe Risk (<30%), Basic (30-49%), Proficient (50-69%), and Advanced (≥70%). The largest group of students, 43.6%, falls within the proficient range, while 35.4% are in the advanced category. However, 21% of students, combining the first two bands, score below the expected minimum threshold of 50%, placing them at

academic risk. This performance distribution shows a relatively strong overall picture but raises an equity concern. It highlights a segment of the student population that is not receiving effective instruction. These performance differences become more significant when considered alongside the CPD levels of their teachers, as shown in Table 4.

Table.4: CPD Intensity and Mean Class Performance.

Teacher Group	CPD Hours	No. of Classes	Mean Score (%)	Class SD
High (≥35 hrs)	35–52	14	66.9	11.2
Medium (25–34 hrs)	25–34	13	62.3	13.4
Low (<25 hrs)	12–24	9	59.1	15.1

Table.4 shows the link between CPD exposure for teachers and the average performance of their students. The data indicates that as CPD hours increase, student performance improves. Teachers with at least 35 hours of CPD had an average class score of 66.9%. In contrast, those with fewer than 25 hours scored only 59.1%. This 7.8-point difference is significant and has been confirmed by ANOVA and post-hoc analysis. It suggests that students whose teachers engage more in CPD tend to perform better. This supports

the idea that CPD contributes to academic performance, backing Objective 2. It also aligns with earlier studies Ambon et al. (2024); Darling-Hammond et al.(2017) and OECD (2016) that showed quality CPD improves student learning outcomes. A one-way ANOVA was conducted to find significant differences in mean class scores among CPD groups. The analysis resulted in  $F(2, 33) = 5.94, p < 0.01$ , which indicates a significant effect. Post-hoc tests showed that students taught by high-CPD teachers scored

an average of 7.8 points higher than those taught by low-CPD teachers. Furthermore, a Pearson correlation coefficient of  $r = 0.46$  ( $p < 0.01$ ) was found between CPD hours and average student scores. This shows a moderate positive relationship between teacher CPD participation and student achievement. These results support earlier research by Ventista & Brown (2023), which found that teachers with significant CPD had a larger impact on student learning outcomes. Although not shown in a table, the correlation and regression findings are important for supporting Objective 2. The Pearson correlation coefficient of  $r = 0.46$  ( $p < 0.01$ ) indicates a statistically significant and moderately strong link between CPD hours and student mathematics scores. Hierarchical regression analysis revealed that CPD accounts for 18% of the variance in

performance, regardless of school location and teacher experience. These results confirm that CPD is associated with better outcomes and serves as a significant predictor of student achievement in mathematics.

### 4.3 Challenges Faced by Teachers in Accessing and Implementing Knowledge gained from CPD in the Teaching of Mathematics.

Table.5 summarizes the most common challenges highlighted during teacher interviews and focus group discussions.

**Table .5: Implementation Challenges Reported by Teachers**

Challenge	Description
Time constraints	CPD sessions overlap with teaching or remedial duties.
Resource shortages	Lack of teaching materials, manipulatives, or internet in rural schools.
Inconsistent mentorship	Mentors are sometimes unavailable for follow-up classroom visits.
Overcrowded classrooms	Difficulties in applying learner-centered strategies with 50+ students.
Limited subject-specific CPD	Some sessions are generic and not focused on mathematics pedagogy.

Table.5 shows the main obstacles teachers face when trying to use what they learned in CPD. The most common barriers include time constraints, especially because of the need to complete the syllabus and prepare students for exams. Teachers also reported a lack of teaching resources, such as manipulatives and ICT tools, especially in rural schools. This matches Wadesango’s (2012) observation that CPD in sub-Saharan Africa often does not lead to impact due to local limitations. Another major issue was inconsistent mentorship. Though school-based mentorship was part of the CPD program, more than 40% of teachers reported not receiving regular support. Without follow-up coaching, the ability to apply new strategies decreases. Large class sizes made it harder to use learner-centered strategies, while some teachers noted that CPD content was not relevant, especially when sessions were not focused on mathematics. These challenges show that while CPD is helpful, its success largely depends on the support for implementation.

### 4.4 Discussion of the Findings

The findings of this study confirm that Continuous Professional Development (CPD) significantly contributes to enhancing both instructional practices and student performance in mathematics. Teachers consistently reported noticeable improvements in their classroom approaches after participating in CPD activities. Over 80%

of respondents agreed or strongly agreed that CPD helped them better understand the Competence-Based Curriculum (CBC), adopt learner-centered methods, and integrate formative assessments and differentiated instruction. These outcomes reflect a growing alignment between teaching strategies and CBC expectations. Such positive perceptions were also validated through classroom observations, which revealed an increase in interactive teaching, continuous feedback, and group-based problem-solving. These results support Guskey’s theory of teacher change, emphasizing that professional growth is reinforced when educators observe improvements in student learning, thus sustaining new instructional behaviors.

More importantly, the study established a quantifiable link between CPD exposure and student academic performance. The analysis of third-term mathematics scores from 305 students revealed an average score of 60.1%, with a wide range from 1% to 97%, highlighting disparities across different classrooms. Students were grouped based on the CPD participation level of their teachers. The data showed that learners taught by teachers who had completed at least 35 hours of CPD scored significantly higher (mean = 66.9%) compared to those whose teachers had fewer than 25 hours of CPD (mean = 59.1%). This difference of 7.8 percentage points was statistically confirmed through a one-way ANOVA test, which yielded  $F(2, 33) = 5.94$ ,  $p < 0.01$ , indicating that

CPD level had a significant effect on student performance. Further post-hoc analysis reinforced this finding, showing that the high-CPD group's performance was significantly different from that of the low-CPD group.

Additionally, the strength and direction of the relationship between teacher CPD hours and student scores were examined using Pearson's correlation. The correlation coefficient was  $r = 0.46$ ,  $p < 0.01$ , signifying a moderate and statistically significant positive relationship. This means that increased CPD participation by teachers tends to be associated with better student outcomes in mathematics. To further explore this connection, a hierarchical regression analysis was conducted. The results showed that CPD hours accounted for approximately 18% of the variance in student performance, even after controlling for variables such as school location and teacher experience. These findings reinforce those of prior international studies Nkundabakura et al. (2024) which emphasized that sustained, content-specific CPD significantly improves learning outcomes in mathematics.

Despite the encouraging impact of CPD, several implementation challenges were noted. Teachers frequently cited time constraints, particularly conflicts between CPD sessions and regular teaching or remedial work. There were also widespread complaints about inadequate teaching resources, especially in rural schools where digital tools and manipulatives are scarce. Mentorship support an essential follow-up mechanism for CPD was often irregular, with over 40% of teachers reporting limited or no classroom-based coaching after training. In schools with large class sizes, often exceeding 50 students, teachers struggled to apply learner-centered strategies effectively. Moreover, some CPD sessions were seen as too general, lacking subject-specific focus on mathematics pedagogy, which limited their usefulness in addressing practical classroom challenges.

Taken together, these findings underscore that while CPD has a positive influence on teaching and learning, its effectiveness depends largely on the quality, intensity, and contextual alignment of the programs. Well-structured CPD that includes sufficient contact hours, subject relevance, mentorship, and follow-up can significantly enhance both instructional competence and student achievement. For Rwanda to fully realize the benefits of CPD in mathematics education, greater investment is needed in ensuring consistent access, contextual relevance, and systemic support across schools. The statistical evidence from this study provides compelling justification for policy and resource allocation decisions aimed at scaling and strengthening CPD initiatives nationwide.

## 5. Conclusion and Recommendations

### 5.1 Conclusion

This study set out to examine the contribution of Continuous Professional Development (CPD) to students' academic performance in mathematics in Rwandan secondary schools. The findings clearly demonstrate that CPD significantly enhances teachers' instructional practices and pedagogical competence, particularly by aligning their teaching with the Competence-Based Curriculum. Teachers who participated in CPD programs reported improvements in learner-centered strategies, assessment practices, and differentiated instruction. Furthermore, empirical evidence established a statistically significant relationship between the extent of CPD exposure and student mathematics performance. Students taught by teachers who had completed more than 35 hours of CPD scored markedly higher than those taught by teachers with limited CPD engagement. The ANOVA test confirmed significant differences in class performance based on CPD levels, while the Pearson correlation coefficient ( $r = 0.46$ ,  $p < 0.01$ ) and regression analysis indicated that CPD accounted for 18% of the variance in student achievement.

However, the study also identified several challenges that hinder the optimal implementation of CPD. These include time constraints, limited teaching resources, insufficient mentorship, overcrowded classrooms, and the general nature of some CPD content that lacks mathematics specificity. These findings underscore that while CPD has great potential to improve mathematics outcomes, its impact is moderated by implementation quality and support structures. Therefore, the study concludes that CPD must be context-responsive, subject-specific, and systematically supported to translate into tangible academic gains.

### 5.2 Recommendation

#### Policy-Level Recommendations

1. Set Minimum CPD Hours: Establish a national policy requiring at least 35 hours of subject-specific CPD annually for mathematics teachers.
2. Revise CPD Framework: Update the national CPD framework to include more mathematics-focused and CBC-aligned content.
3. Ensure Equity in CPD Access: Allocate resources to support CPD in rural schools, including internet, materials, and transport allowances.
4. Monitor CPD Impact: Develop a national system to track teacher participation and evaluate CPD effectiveness using student performance data.

5. Include Inclusive Education: Integrate inclusive teaching strategies into all CPD programs to support diverse learners.

### Practical-Level Recommendations

1. Strengthen Mentorship: Ensure regular, school-based mentorship and peer support for continuous improvement.
2. Localize CPD Delivery: Organize CPD sessions at school or sector levels to address context-specific needs.
3. Manage Time and Resources: Schedule CPD sessions during non-teaching periods and provide adequate teaching materials.
4. Encourage Reflective Practice: Support teachers in keeping teaching portfolios to apply and assess CPD knowledge.
5. Use Student Feedback: Incorporate student input to evaluate the classroom impact of CPD on learning experiences.

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