

# Collaborative Learning through Technology: Secondary School Mathematics Teachers' Perspectives on Digital Professional Communities

Onesme Niyibizi

*Institut Catholique de Kabgayi (ICK), Rwanda*

<i>Keywords</i>	<b>Abstract</b>
digital professional communities, collaborative learning, secondary mathematics teachers, online peer-sharing platforms	This study explored secondary mathematics teachers' perceptions of digital professional communities and their role in professional learning, collaboration, and instructional innovation. Using a qualitative approach, 120 teachers from public and private secondary schools in Rwanda's South Province were purposively selected and interviewed. Findings indicated that online communities and peer-sharing platforms enhanced access to different teaching resources, improved collaboration, and supported problem-solving, while also reducing professional isolation and providing psychosocial benefits. Teachers reported improved pedagogical confidence, motivation, and opportunities for mentorship and cross-border collaboration. However, challenges such as poor internet connectivity, digital literacy gaps, time constraints, and limited institutional support delayed full engagement, particularly in rural contexts. The study recommends investment in digital infrastructure, targeted capacity building, and institutional support to optimise the potential of digital professional communities for secondary mathematics teachers.

## Introduction

The integration of technology in education has transformed the ways teachers access professional development, collaborate, and refine their instructional practices (Edu, 2025). Despite this global shift, in many secondary schools, particularly in regions like Rwanda's South Province, mathematics teachers face challenges in leveraging digital platforms effectively. While formal professional development programmes exist, they are often limited in scope, accessibility, and responsiveness to teachers' immediate classroom needs. Consequently, teachers frequently encounter gaps between the ideal of continuous, collaborative learning and the reality of constrained opportunities for peer engagement, knowledge exchange, and instructional innovation. This disconnect reduces the quality of mathematics instruction and limits students' learning outcomes, highlighting a pressing need to explore alternative avenues for teacher support.

Digital professional communities, including online networks and peer-sharing platforms, offer promising solutions by facilitating collaborative learning, resource exchange, and problem-solving among teachers (Septiani et al., 2025). However, empirical evidence on how secondary mathematics teachers perceive and utilise these platforms remains limited, particularly in the



Rwandan context (Mushimiyimana et al., 2025). In many secondary schools, teachers continue to struggle with inadequate digital infrastructure, limited access to reliable internet connectivity, and insufficient training on the effective integration of digital tools into mathematics instruction. These challenges often result in low confidence, inconsistent use of learning platforms, and a reliance on traditional teaching methods. Consequently, even where digital platforms are available, teachers may be unable to fully exploit their potential to enhance learner engagement and achievement.

Most studies in Rwanda have concentrated either on student learning outcomes or the integration of digital tools within specific subjects, such as biology, and English language instruction. For example, Uwitonze and Nizeyimana (2022) examined how virtual simulations enhanced students' conceptual understanding in biology, while Ndahayo and Ndayambaje (2024), in their study, found that inadequate teaching and learning resources for integrating Computer-Assisted Language Learning (CALL) in Technical Secondary Schools in Nyanza District hinder improvements in students' English performance, highlighting the need for the Ministry of Education to provide sufficient computers and reliable internet connectivity. Although these studies highlight the growing use of digital technologies across subjects, they primarily emphasise classroom teaching and student performance rather than teachers' professional engagement within digital networks (Iyamuremye et al., 2025; Nzarugarura & Ndagijimana, 2025).

Consequently, research focusing specifically on how mathematics teachers participate in and benefit from digital professional communities is still scarce in Rwanda. Understanding teachers' experiences illuminates both the potential and challenges for these communities, informing strategies to optimise their use for professional growth. The study contributes to the existing literature by providing in-depth, qualitative insights into teachers' lived experiences, bridging the gap between theory and practice in the digital professional development landscape.

Motivated by the need to enhance mathematics teaching quality and improve sustainable professional learning, this study explored secondary mathematics teachers' perceptions of digital professional communities.

By focusing on teachers actively engaged in online collaboration, the research captures perspectives on instructional improvement, peer support, and the role of technology in increasing innovation. The findings were expected to inform policy makers, school administrators, and educators about best practices in integrating digital communities into teacher development initiatives. Furthermore, this current study offers practical recommendations for designing supportive, accessible, and effective digital platforms that empower mathematics teachers, thereby contributing to both professional practice and the broader educational research community.

## **Literature Review**

Research consistently shows that online professional communities provide teachers with access to different pedagogical strategies and global teaching resources, thereby enhancing instructional practices (Chasokela & Mpofu, 2025; Shauly & Avargil, 2025). Moreover, teachers report improved confidence in teaching complex topics, greater motivation to experiment with innovative assessment methods, and emotional support through peer interaction (Köpeczi-Bócz, 2025). Interestingly, private school teachers tend to adopt these platforms more readily, reflecting differences in digital readiness and institutional support, while rural teachers often face connectivity limitations (Li, 2025; Naveed et al., 2025). Taken together, these findings

underscore the capacity of digital networks to increase professional growth while highlighting contextual inequities. Notably, this aligns with prior literature on the transformative potential of online communities, yet contributes new insights on affective and linguistic gains, particularly in low-resource settings.

In addition, studies highlight that peer-sharing platforms encourage real-time collaboration and collective problem-solving, provide immediate pedagogical support and flatten traditional hierarchical structures (Blyznyuk et al., 2025; Oni & Ngongpah, 2025). For example, teachers engage in co-developing teaching aids, sharing resources, and providing peer feedback, raising accountability and professional discipline beyond mere content exchange (Vääätäjä, 2025). Even more importantly, passive participation also contributes to learning, as teachers observe strategies before implementation (Mercado & Shin, 2025). Thus, this extends the existing literature by reframing passive observation as a legitimate mode of professional learning and emphasising mentorship reconfiguration in digital spaces.

At the same time, digital professional communities present opportunities such as enhanced access to resources, mentorship, professional recognition, and cross-border collaborations (Chasokela et al., 2025; Subrahmanyam, 2026). However, barriers including connectivity issues, digital literacy gaps, workload pressures, and information overload impede engagement (Koch & Fehlmann, 2025). Importantly, teachers' reflections highlight that institutional support and recognition are critical for sustained participation (Lapidot-Lefler, 2025).

Although existing studies demonstrate that online professional communities enhance teachers' access to pedagogical strategies, promote collaboration, and strengthen emotional and motivational support, much of this evidence is drawn from general teaching contexts, mixed subject groups, or technologically advanced settings. Limited research specifically examines how secondary mathematics teachers, particularly in resource-constrained or rural environments, experience and utilise these digital communities for professional learning. Furthermore, while recent scholarship highlights affective benefits, mentorship reconfiguration, and the legitimacy of passive participation, little is known about how these dynamics unfold within mathematics teaching, where conceptual complexity and curriculum demands differ significantly. This gap underscores the need for a focused investigation that integrates both the contextual barriers (such as digital readiness, connectivity, and institutional support) and the professional affordances of online communities for mathematics teachers. The present study seeks to address this underexplored intersection.

This current study therefore contributes a perspective that integrates both structural barriers and psychosocial benefits, advancing the discourse on sustainable digital professional development in resource-constrained educational contexts.

### **Research Questions**

The current study aimed to answer the following research questions:

1. How do secondary mathematics teachers perceive the role of online communities and digital networks in enhancing their professional learning and instructional practices?
2. In what ways do peer-sharing platforms and digital professional communities facilitate collaboration, knowledge exchange, and problem-solving among secondary mathematics teachers?
3. What challenges and opportunities do secondary mathematics teachers encounter when engaging in digital professional communities for their professional growth?

## **Methods**

In Rwanda, technology-enabled learning has been progressively promoted through national initiatives such as the ICT in Education Policy, the Smart Classroom programme, and the integration of digital platforms for teacher professional development. While access to digital infrastructure and online professional communities has expanded, particularly in secondary schools, teachers' levels of digital engagement and pedagogical use of technology remain uneven across regions and school types. This study is situated within this evolving national context and seeks to generate empirical insights into how secondary mathematics teachers engage with digital professional communities and technology-supported pedagogical practices, thereby contributing evidence to ongoing efforts to strengthen technology-enabled teaching and learning in Rwandan schools.

### **Research Approach**

This study employed a qualitative research approach to explore secondary mathematics teachers' perceptions of digital professional communities. Specifically, it adopted a phenomenological research design to capture teachers' lived experiences and the meaning they attach to their participation in online professional networks. Qualitative methods were chosen to capture in-depth, context-rich insights into teachers' experiences with online communities, peer-sharing platforms, and digital networks. This approach allowed the study to explain the ways in which teachers engage with digital resources for professional growth, instructional practices, and collaboration.

### **Participants**

The study purposively selected 120 secondary mathematics teachers from both public and private secondary schools in the South Province, Rwanda. Teachers were chosen based on their willingness to participate and their active engagement with digital professional communities.

Purposive sampling was used because the study sought information-rich participants who were actively involved in digital pedagogical practices, making them the best positioned to provide deep insights into the phenomenon under investigation. The South Province was specifically selected due to its diverse mix of rural and urban schools, its ongoing investment in ICT integration, and its documented variability in teachers' access to online professional platforms, which provided an ideal context for examining differences in digital engagement. The study considered teachers' experiences with online collaboration, digital lesson design, problem-solving in virtual communities, and the use of technology to support instructional innovation, ensuring that participants had practical exposure relevant to the research aims. This sampling strategy ensured that participants had relevant experience and provided rich qualitative data regarding online collaboration, problem-solving, and instructional innovation.

### **Instrument**

Data were collected through semi-structured interviews, allowing participants to express their views on the benefits, challenges, and opportunities of digital professional engagement. The interview protocol included open-ended questions aligned with the three research questions regarding: perceptions of online communities, collaborative practices through peer-sharing platforms, and the challenges and opportunities encountered. This approach enabled participants to share detailed personal experiences while providing consistent data across the sample.

**Procedure**

Interviews were conducted in participants' schools and via online video calls, depending on accessibility and teacher preference. Each interview lasted approximately 40-60 minutes and was audio-recorded with the participants' consent. Follow-up questions were used to probe deeper into responses and clarify ambiguous statements. Field notes were maintained to capture non-verbal cues and contextual information.

**Data Analysis**

Data were analysed using narrative analysis, following a six-step process: familiarisation with the data through repeated reading; identification of meaningful narrative segments; coding of recurring ideas and experiences; construction of coherent narratives; interpretation of patterns across narratives; and validation of findings through iterative comparison with the original data.

**Trustworthiness**

The study ensured trustworthiness through credibility, transferability, dependability, and confirmability. Member checking was conducted by sharing preliminary findings with selected participants for validation. Triangulation was achieved by comparing responses across teachers from different school contexts (public vs. private, rural vs. urban). Detailed field notes and audit trails documented the research process to enhance transparency and dependability.

**Ethical Considerations**

Ethical approval was obtained from the Institut Catholique de Kabgayi, and participants provided informed consent prior to the study. Confidentiality was maintained by assigning pseudonyms, and participants were informed of their right to withdraw at any stage. Data were securely stored on password-protected devices, and findings were reported without identifying individual teachers to protect privacy.

**Limitation**

While the qualitative approach provided rich insights, the study was limited by its reliance on self-reported data, which could be subject to social desirability bias. Additionally, the purposive sample from South Province limits generalisability to other regions. Nonetheless, the methodology was appropriate for exploring teachers' lived experiences with digital professional communities, and the findings offer valuable implications for policy, practice, and further research.

**Results**

The study involved 120 secondary mathematics teachers from both public and private schools in South Province, Rwanda, who were purposively selected based on their willingness to participate. Among them, 78% (n = 94) reported active engagement with online communities, while 22% (n = 26) indicated minimal impact from digital networks. Teachers from private schools constituted a significant portion of those perceiving high benefits (64%), whereas rural teachers (37%) reported limited gains due to connectivity issues. Participation across professional networks varied by age, digital literacy, and teaching experience, with older teachers and those with lower digital skills reporting challenges in engagement. Both male and female teachers were represented, and participants spanned various teaching levels, with a mix of urban and rural settings influencing access to resources, mentorship, and professional learning opportunities.

**Research Question 1: How do secondary mathematics teachers perceive the role of online communities and digital networks in enhancing their professional learning and instructional practices?**

A majority of the participants (78%,  $n = 94$ ) expressed that online communities were crucial in broadening their access to new teaching strategies and resources. Many emphasised that these platforms provided exposure to global best practices. One teacher stated, *“I can now teach topics like calculus more effectively after engaging with peers in international forums.”* Teachers from private schools (64%) were particularly positive about the integration of online communities, linking them with improved lesson planning and classroom engagement. A participant remarked, *“Our WhatsApp group for mathematics teachers has been like a library at my fingertips.”* Conversely, 22% of teachers ( $n = 26$ ) reported minimal impact from digital networks, citing limited relevance to their immediate classroom needs. One explained, *“Sometimes, the discussions are too theoretical and not adapted to our context.”*

Furthermore, a number of teachers (61%,  $n = 73$ ) highlighted that online communities increased their motivation to innovate, as they linked exposure to digital collaboration with trying out new assessment strategies. About 49% of the teachers stressed that online networks provided confidence in handling challenging concepts such as geometry proofs. Teachers from rural districts (37%) perceived less benefit compared to their urban counterparts, attributing this gap to internet connectivity issues. A group of teachers (58%,  $n = 70$ ) emphasised that online professional learning reduced their sense of isolation, while some (33%,  $n = 40$ ) indicated they relied on digital communities mainly for updates on curriculum reforms.

Some teachers (41%,  $n = 49$ ) also acknowledged that online forums provided emotional support, beyond technical knowledge. Interestingly, 27% ( $n = 32$ ) noted that online communities improved their English proficiency, which indirectly enhanced their teaching. While the benefits were clear, 19% ( $n = 23$ ) of teachers reported being overwhelmed by the volume of resources shared online. Overall, teachers perceived online communities as valuable, though the extent of the benefit varied depending on access, relevance, and personal engagement.

**Research Question 2: In what ways do peer-sharing platforms and digital professional communities facilitate collaboration, knowledge exchange, and problem-solving among secondary mathematics teachers?**

An overwhelming 83% ( $n = 100$ ) of teachers agreed that peer-sharing platforms significantly supported collaboration. They emphasised that online collaboration allowed quick responses to teaching challenges. One noted, *“Within minutes, I can get ideas for handling a difficult algebra problem.”* Teachers from public schools (52%,  $n = 63$ ) reported that peer-sharing networks bridged gaps between experienced and novice teachers. One participant stated, *“Senior teachers freely share lesson notes, which saves us time.”* About 55% of respondents linked peer-sharing platforms with improved problem-solving. A participant mentioned, *“When students struggle, I post my challenge, and colleagues suggest multiple approaches.”*

Nearly half of the teachers (47%,  $n = 56$ ) used these platforms to co-develop digital teaching aids, such as interactive PowerPoints. One participant reflected, *“Our group helped me design a simulation for trigonometry, which worked wonders.”* Some teachers (39%,  $n = 47$ ) indicated that peer-sharing enabled them to adapt foreign materials to their local curriculum. One teacher explained, *“We discuss how to simplify international resources for our students.”* Some teachers (28%,  $n = 34$ ) emphasised that collaboration extended beyond mathematics into broader professional issues, such as student discipline. One participant said, *“We don’t just share about mathematics, but about managing classrooms effectively.”*

Digital platforms were also seen by some (44%,  $n = 53$ ) as a means of professional accountability. One teacher noted, *“When I promise to try a method, I know colleagues will ask about the results, which keeps me committed.”* Around 60% of teachers ( $n = 72$ ) valued the peer feedback on lesson plans they shared online. A teacher remarked, *“The comments from others helped me polish my lesson plan before using it in class.”* While collaboration was praised, 23% ( $n = 28$ ) admitted they rarely contributed but mostly observed, a practice known as “lurking.” One participant confessed, *“I read and learn from others, but I hardly post.”*

Roughly half the teachers (51%,  $n = 61$ ) highlighted that peer-sharing platforms increased creativity in problem-solving by exposing them to different perspectives. A respondent shared, *“I never thought of teaching quadratic equations using games until I read about it.”* A minority (17%,  $n = 20$ ) noted conflicts sometimes arose in discussions due to differences in opinion. One explained, *“We argue a lot about which teaching method is best.”* Overall, peer-sharing platforms function as vibrant spaces of collaboration, where teachers blend knowledge exchange with joint problem-solving, though participation levels vary. As one participant summarised, *“It is like a collective brain that strengthens our individual practice.”*

### **Research Question 3: What challenges and opportunities do secondary mathematics teachers encounter when engaging in digital professional communities for their professional growth?**

Teachers widely acknowledged opportunities, with 76% ( $n = 91$ ) citing enhanced access to different teaching materials as the greatest benefit. One said, *“The resources online are richer than what we have in our school library.”* At the same time, 42% ( $n = 50$ ) identified poor internet connectivity as the most significant challenge. A teacher expressed, *“Sometimes I miss important discussions because the network is down.”* Some participants (33%,  $n = 40$ ) mentioned digital literacy gaps as barriers, particularly among older teachers. One noted, *“I feel left behind when others share complex tools I cannot use.”*

A majority of teachers (58%,  $n = 70$ ) emphasised that engaging in professional communities broadened their career opportunities. A teacher stated, *“I was invited to facilitate a workshop after colleagues saw my online contributions.”* However, 29% ( $n = 35$ ) reported time constraints due to heavy teaching loads. A participant said, *“I hardly get time to log in during weekdays.”* Security and privacy concerns were mentioned by 21% ( $n = 25$ ). One teacher reflected, *“I hesitate to share my lesson plans because I fear they may be misused.”* Opportunities for mentorship emerged strongly (64%,  $n = 77$ ), as teachers described supportive relationships formed online. A respondent stated, *“I have a mentor from another district whom I met on Facebook.”*

Despite challenges, 37% ( $n = 44$ ) of teachers said digital communities enhanced their recognition and visibility. A participant explained, *“When my post is appreciated, I feel valued as a professional.”* Some teachers (48%,  $n = 58$ ) identified lack of institutional support as a barrier, noting that schools rarely allocated resources for online learning. A teacher commented, *“We use personal data bundles, and the cost is high.”* At the same time, 55% ( $n = 66$ ) pointed to the opportunity for cross-border collaborations. A participant highlighted, *“I now collaborate with teachers in Kenya and Uganda, which has opened my eyes.”* Interestingly, 24% ( $n = 29$ ) reported experiencing information overload. One teacher explained, *“Too many posts make it hard to focus on what is important.”*

Overall, the findings suggest that while challenges of access, literacy, and support persist, opportunities for professional growth, mentorship, and global collaboration make digital communities an essential tool for teachers. One summarised, *“The challenges are real, but the opportunities are greater.”*

## Discussion

### Secondary Mathematics Teachers Perceive Online Communities and Digital Networks as Transformative Tools

The findings reveal that the majority of teachers recognised online communities as transformative spaces for professional growth, particularly in expanding access to different pedagogical strategies and teaching resources. With 78% of teachers acknowledging their usefulness, it is evident that digital platforms were perceived as a bridge to global best practices. This finding supports earlier studies (e.g., Chasokela & Mpofu, 2025; Shauly & Avargil, 2025) which emphasised that digital communities enrich teachers' pedagogical repertoires and encourage classroom innovation.

Interestingly, private school teachers demonstrated a stronger inclination (64%) toward the adoption of these platforms compared to their public-school counterparts, citing advantages in lesson preparation and engagement. Conversely, 22% of teachers expressed reservations, largely due to a mismatch between online discourse and local classroom realities. This highlights a tension between globally shared knowledge and locally contextualised pedagogy. This partially contradicts findings by Köpeczi-Bócz (2025), who reported that online communities largely transcend contextual barriers, indicating that local realities still strongly mediate online engagement in Rwanda's context.

Motivation and innovation also emerged as strong outcomes of digital participation, with 61% reporting greater willingness to experiment with assessment strategies. Likewise, almost half (49%) stressed increased confidence in teaching complex topics. However, the digital divide was evident in rural contexts, where only 37% reported substantial benefits, attributing their limited participation to connectivity challenges. This aligns with the prior study of Li (2025) highlighting digital divides, but it contributes a new dimension by showing how inequities manifest not only in access but also in differential pedagogical confidence among teachers.

Beyond technical skills, teachers also emphasised the emotional and social dimensions of online networks. Fifty-eight percent highlighted reduced professional isolation, while 41% pointed to emotional support as a valuable aspect. Additionally, the observation that 27% improved their English proficiency through daily online interactions illustrates an indirect but important benefit. Still, some teachers (19%) reported being overwhelmed by the abundance of materials, signaling the need for guidance to optimise learning. Overall, teachers regarded digital networks as valuable professional ecosystems, yet their effectiveness was mediated by access, contextualisation, and teachers' individual engagement. This extends previous literature by emphasising affective and linguistic gains, which are rarely highlighted in digital professional learning studies, thus offering a new contribution to the body of knowledge.

### Peer-Sharing Platforms and Digital Communities Facilitate Collaboration, Knowledge Exchange, and Problem-Solving

The results strongly demonstrate that peer-sharing platforms are central to increasing collaboration, with 83% of teachers citing them as essential to addressing instructional challenges. This responsiveness contrasts with traditional professional development, which is often periodic and top-down. This supports findings by Oni and Ngongpah (2025), who argued that peer-driven digital communities offer timely and practical solutions compared to conventional professional development.

Collaboration appears to transcend experience levels, with public school teachers (71%), in particular, noting that senior colleagues' generosity in sharing resources reduced the workload

for novices. Additionally, problem-solving was a recurring theme, as 55% described how collective brainstorming provided multiple approaches to persistent student difficulties. The co-development of teaching aids, reported by nearly half the teachers (47%), further reflects how digital collaboration translates into tangible classroom tools. This is consistent with prior research (e.g., Blyznyuk et al., 2025), but the emphasis on flattening hierarchies contributes fresh insights into how peer-sharing reconfigures mentorship dynamics in mathematics education.

Teachers also revealed that collaboration was not limited to mathematics content but extended into professional domains such as classroom management and discipline. Importantly, 44% of the teachers recognised these platforms as heightening accountability, with peer monitoring encouraging follow-through on instructional commitments. Similarly, peer feedback on lesson plans (60%) illustrates the participatory nature of digital learning communities. This partially contradicts earlier studies that framed online spaces as primarily resource-sharing platforms (e.g., Väättäjä, 2025), since here they also functioned as accountability and professional discipline mechanisms.

Nevertheless, challenges in engagement remained. About 23% of the teachers admitted to passive participation and benefiting from others' contributions without actively engaging. While this reflects uneven participation, it also indicates that professional learning occurs along a spectrum. According to some (17%), conflicts arising from differing methodological views highlight the diversity of pedagogical perspectives but also point to the need for effective facilitation within digital groups. Overall, peer-sharing platforms function as collective professional "brains," where collaboration, critique, and creativity merge, though the inclusiveness of participation varies. This contributes new insights to the literature by reframing passive participation not as a deficit but as a legitimate mode of professional learning, challenging traditional assumptions of online engagement.

### **Teachers Encounter both Challenges and Opportunities in Engaging with Digital Professional Communities for Professional Growth**

The findings highlight a dual narrative of significant opportunities alongside persistent challenges. On the one hand, enhanced access to resources was the most widely cited benefit (76%), with teachers recognising that online platforms offer richer content than physical school libraries. Moreover, professional growth opportunities, such as mentorship (64%) and expanded career visibility (37%), emerged as important outcomes. Similarly, cross-border collaborations (55%) with teachers in neighboring countries demonstrated that digital platforms expand professional perspectives beyond national boundaries. This aligns with findings from Chasokela et al. (2025) that online networks enhance professional recognition, but the evidence of regional collaborations adds a new contribution by situating the findings within cross-border educational dynamics.

On the other hand, structural and personal barriers continue to impede full participation. Connectivity issues were the most pressing challenge, affecting 42% of teachers, particularly in rural contexts. Digital literacy gaps (33%), especially among older teachers, revealed generational divides. Furthermore, time constraints (29%) due to heavy teaching loads illustrated how systemic workload issues intersected with digital participation. Security and privacy concerns (21%) also surfaced. These findings confirm challenges identified in previous studies (e.g., Subrahmanyam, 2026), but the intersection of systemic workload and digital engagement introduces a novel perspective that requires institutional policy consideration.

Another recurring theme was information overload (24%), where the abundance of resources delayed effective learning. Coupled with the lack of institutional support (48%), where

teachers often used personal funds for data bundles, these challenges suggest that systemic support structures are necessary for sustained engagement. Despite these barriers, the overarching sentiment among teachers was that opportunities outweighed challenges. This contradicts narrow functionalist views of digital platforms as resource repositories (e.g., Koch & Fehlmann, 2025), by highlighting their affective and motivational roles in sustaining teacher engagement.

Overall, while challenges of access, literacy, and institutional support persist, teachers overwhelmingly viewed digital professional communities as indispensable for professional growth. This current study therefore contributes a perspective that integrates both structural barriers and psychosocial benefits, advancing the discourse on sustainable digital professional development in resource-constrained educational contexts.

### Conclusion and Recommendations

The findings of this study contribute to the existing knowledge base by extending current debates on teacher professional development in digital environments. Specifically, the study provides empirical evidence from a Rwandan context, demonstrating how digital professional communities function not only as instructional support systems but also as psychosocial support mechanisms, an area underexplored in Sub-Saharan Africa. Moreover, the study reinforces and expands theoretical perspectives on social learning, collaborative knowledge building, and digital participatory culture by showing how these frameworks manifest in low-resource educational settings. This work also fills a gap by highlighting context-specific barriers to participation, thus offering critical insights for strengthening equity-focused digital professional development policies and interventions.

Based on these findings, it is recommended that educational stakeholders invest in robust digital infrastructure and affordable internet access to ensure equitable participation. Professional development programmes should include training to improve digital literacy, especially for older and less digitally experienced teachers. Schools and districts should provide institutional support, including dedicated time and resources for online engagement, while platform facilitators should implement strategies to manage information overload and encourage active participation. Additionally, policy frameworks could promote localised adaptation of shared resources to ensure relevance to Rwandan classrooms. These measures should maximise the benefits of digital professional communities, boosting both pedagogical and psychosocial growth among secondary mathematics teachers.

Future research should empirically examine how variations in digital infrastructure quality and internet affordability directly influence levels of participation and pedagogical outcomes within digital professional communities. Longitudinal studies are also needed to assess how sustained digital-literacy training, particularly for older and less digitally experienced teachers, affects engagement and professional growth over time. In addition, experimental or comparative studies could explore the effectiveness of different platform-level strategies for managing information overload and increasing active participation in localised Rwandan secondary mathematics contexts.

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### Author Notes

**Onesme Niyibizi** is a PhD candidate in Mathematics Education at the University of Rwanda and currently serves as an Assistant Lecturer at the Institut Catholique de Kabgayi (ICK), Rwanda. His research interests focus on mathematics teaching methodologies, student motivation, and innovative instructional practices in higher education. Email: [niyibizionesme12@gmail.com](mailto:niyibizionesme12@gmail.com) (<https://orcid.org/0000-0002-4066-5678>)

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