

 Research Article

Continuous Professional Development and the Adoption of Innovative Teaching Methods: Evidence from Mathematics Teachers in Rural Rwanda

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Abstract

This study explores the extent to which mathematics teachers in rural areas in Rwanda shift from teacher-centered to learner-centered approaches while implementing the CPD ITMS curriculum, an aspect of CPD ITMS that prior research has not examined. Using a convergent mixed-methods design, questionnaires were used to collect data from thirty mathematics teachers and fifteen deputy headteachers from schools in Ngoma District, and the findings were analyzed using SPSS; classroom observation and interviews were used to validate the findings from the questionnaire. Teachers showed high confidence ($M = 4.57$), readiness ($M = 4.64$), but low implementation ($M = 3.29$) and a poor feedback system ($M = 2.45$). Teachers tried to employ innovative teaching techniques to achieve learning outcomes; however, class size, frequent interruption by other staff, and lack of ICT materials were obstacles to this work. Deputy headteachers agreed that CPD ITMS contributed positively to building the capacity of teachers; however, the lack of training for the deputy headteachers on the CPD ITMS prevented them from supervising teacher learning properly. It is evident that CPD ITMS positively contributed to capacity building, but sustainability will rely on mentoring, school management, ICT investment, and the inclusion of adoption (implementation) indicators in the evaluation process. The limitation of conducting this study in one district only shows the need for further research on the connection between CPD adoption and learners' learning achievements.

Keywords: Continuous Professional Development, Innovative Teaching Methods, Mathematics Education, Pedagogical Innovation, Teacher Training, Learner-Centered Pedagogy

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1. INTRODUCTION

Mathematics education is widely recognized as a cornerstone of national development, equipping learners with analytical reasoning, problem-solving, and quantitative skills essential for participation in a knowledge-based economy (World Bank, 2020). In Rwanda, mathematics holds a central place within the Competence-Based Curriculum (CBC), which promotes learner-centered instruction, critical thinking, and the practical application of knowledge (MINEDUC, 2015). This reform encourages teachers to move away from traditional, teacher-dominated approaches and instead adopt innovative methods that actively engage students in the learning process.

In order to achieve this goal, the Rwanda Basic Education Board (REB) introduced a number of CPD programs, among which is CPD in Innovative Teaching Methods for Mathematics and Science (ITMS). In CPD ITMS, teachers learn different methods of teaching such as inquiry-based learning, ICT use, teamwork, and project-based teaching, and all these methods are aimed at bringing classroom activities in line with the CBC approach and boosting learner performance (REB, 2020). However, experience shows that despite CPD ITMS increasing teachers' confidence, the lack of ICTs, classroom overcrowding, and poor mentoring make the program unsustainable in rural Rwanda (Kubwimana & Nzabalarwa, 2026a).

Globally, CPD has been shown to enhance teacher effectiveness when it is sustained, context-specific, and supported by institutional structures. Japan's lesson study emphasizes collaborative planning and reflection (Lewis & Takahashi, 2013); Singapore integrates mentoring and ICT into CPD frameworks (Gopinathan, 2012), and Finland prioritizes equity and teacher autonomy in professional development (Sahlberg, 2011). In Sub-Saharan Africa, Kenya's SMASSE programme demonstrated improvements in active learning strategies but faced sustainability challenges due to resource constraints (Omare et al., 2019). These examples highlight that CPD is most effective when embedded within supportive institutional systems.

Although CPD ITMS has been implemented all over the country in Rwanda, one major challenge remains unaddressed: the availability of empirical evidence concerning the impact of training on the adoption of the ITMS in classrooms. Rural schools face the greatest challenges, including class congestion, shortage of materials, and unstable ICT infrastructure (Munyaneza, 2022). In addition, the deputy headteachers tasked with managing the teaching processes do not appear to benefit directly from the CPD ITMS training (Nkundabakura et al., 2024).

The study explores how much CPD ITMS influences the incorporation of innovative teaching techniques by mathematics teachers in Ngoma District. Specifically, it investigates whether CPD ITMS training leads to measurable changes in classroom practices, identifies barriers to implementation, and explores the role of institutional support in sustaining innovation. By focusing on adoption rather than perceptions, this study contributes unique insights distinct from prior research and complements existing literature on teacher professional development in Rwanda. The results are expected to guide policymakers, education stakeholders, and classroom practitioners in understanding how CPD ITMS advances innovative teaching practices. Beyond immediate implications, the findings establish a foundation for future investigations, particularly longitudinal studies that can evaluate the long-term sustainability of CPD outcomes and their influence on student learning. Evidence from other structured pedagogical interventions in Rwanda, such as remedial education programmes, similarly points to a positive link between sustained instructional support and measurable gains in student performance (Bigirimana, Nzabalinwa, & Habimana, 2026).

1.1. Literature Review

1.1.1. Global evidence on CPD and innovative teaching

Continuous Professional Development (CPD) is recognized as an important aspect of educational reform. As recent comparative analyses have shown, successful CPD emphasizes the importance of personalized, collaborative learning processes and research practices (Agranovich et al., 2024). A broader systematic review of the CPD literature corroborates this pattern, showing that CPD improves teaching quality most consistently when it is sustained and embedded within supportive leadership and collaborative structures (Ambon, Alias, Komariah, & Mansor, 2024). Japan's lesson study remains a global benchmark, fostering reflective practice through collaborative lesson planning and peer observation (Lewis & Takahashi, 2013). Equivalent lesson study cycles have also proven to be effective in improving the problem-solving skills of mathematics students through teaching using problem-solving methods (Roorda et al., 2024). Singapore integrates mentoring, ICT use, and inquiry-based learning into CPD frameworks, ensuring sustained support for novice teachers (Gopinathan, 2012; Bautista et al., 2015). Finland continues to prioritize equity and teacher autonomy, embedding research-based CPD into career trajectory and allowing adaptation to local contexts (Sahlberg, 2011). These examples demonstrate that CPD is most effective when it is sustained, collaborative, and contextually relevant (Garet et al., 2001; Desimone, 2009), and when lessons are highly applicable to Rwanda's evolving education system.

1.1.2. African Context of CPD

In Sub-Saharan Africa, CPD initiatives have been required to address systemic challenges such as large class sizes, limited resources, and underqualified teachers. Kenya's Strengthening Mathematics and Science in Secondary Education (SMASSE) programme improved teacher competence in active learning strategies but struggled with sustainability due to resource shortages and inconsistent follow-up (Omare et

al., 2019). Uganda's peer mentoring and subject-specific workshops fostered collaboration and reflective practice, though scalability remained problematic (Wabule, 2016). More recent African studies emphasize that CPD must be localized and supported institutionally to sustain outcomes (UNESCO, 2023).

1.1.3. Rwanda's CPD ITMS context

Continuous Professional Development (CPD) has been placed at the center of educational reforms in Rwanda. This is seen in the implementation of CPD in the Innovative Teaching Methods for Mathematics and Science (ITMS) program by the Rwanda Education Board (REB), in connection with the Competence-Based Curriculum (REB, 2020). Large-scale studies have confirmed the program's positive impact. Evaluations conducted nationally on the Rwanda Quality Basic Education for Human Capital Development Project show significant increases in the pedagogical content knowledge of upper primary school teachers after undergoing CPD ITMS training (Nkundabakura et al., 2024a). There have been increases in the pedagogical, technological, and content knowledge of secondary teachers, as well (Nkundabakura et al., 2024b); this is alongside evidence from datasets showing the effectiveness of CPD ITMS in terms of the improvements it brings to upper primary and lower secondary school teachers (Nkundabakura et al., 2024). CPD ITMS has additionally been shown to increase the involvement and self-efficacy of female teachers in mathematics and sciences (Nkundabakura et al., 2025), and pedagogical knowledge of lower secondary teachers (Nyirahabimana et al., 2026), to build teachers' skills through the co-development of scripted lessons (Nsengimana et al., 2024), and to support teachers' use of innovative tools and the 5Es instructional model (Byukusenge et al., 2024). At the classroom level, sustained CPD participation has been linked to improved student performance in mathematics (Ntawuzibyanikora, 2025).

Additional studies have identified structural weaknesses that limit the effectiveness of the program. As noted by Nkundabakura et al. (2024), the deputy headteachers tasked with overseeing teaching methods do not directly benefit from CPD ITMS, leading to weak feedback and mentoring mechanisms. Recent evidence from Ngoma district supports this notion since CPD ITMS increases teachers' confidence levels but is faced with structural challenges such as shortage of resources, poor mentoring, and lack of supervision (Kubwimana & Nzabalinwa, 2026a).

Consequently, the outcomes collectively suggest that CPD ITMS results in a significant improvement in the teachers' knowledge and confidence, but the influence on the actual teaching practice is sporadic. Clearly, there is an urgent need for stronger institutional backing, inclusion of the school management in CPD courses, as well as provision of funds for ICT and classroom equipment.

1.1.4. Theoretical Frameworks

The current research is based on two major theories, in addition to social and situated learning theories (Vygotsky, 1978; Wenger, 1998). The Social Learning Theory of Bandura (1977) is centered on learning via observing, imitating, and being informed about one's performance, which correlates with the collaboration and peer-learning principles of CPD ITMS. Recent studies in CPD in Rwanda have suggested that peer observation and collaboration are vital factors that lead to the acceptance of innovations. Guskey's model of teacher change (2002) states that CPD should not only develop teacher knowledge and skills but also alter their attitudes and beliefs. Updated evidence supports this: CPD ITMS shifts teacher attitudes, but without institutional support, behavioral change remains inconsistent (Nkundabakura et al., 2024).

1.1.5. Identified gaps in Literature

While there is an increasing number of studies worldwide and regionally on the subject of Continuous Professional Development (CPD), certain gaps still exist in relation to Rwanda. Most of the research carried out from 2023 to 2024 was based on the evaluation of teachers' knowledge gains but did not look into the further implementation of innovation within classrooms. Relatively few researchers have paid attention to the CPD ITMS in rural areas where certain barriers include lack of resources, large classroom size, and underdeveloped ICT infrastructure. The role of institutions, specifically deputy

headteachers and school management, has been underrepresented in the literature, and it remains unclear what the impact of supervisory structures on the sustainable development of CPD outcomes could be. In addition, there has not been any longitudinal study on how effective CPD ITMS is for students' achievement of learning outcomes. This study is intended to fill some of the gaps mentioned above by changing the focus from perception to adoption and looking at rural environments where the barriers are more visible.

2. METHODOLOGY

This part explains the research design, the participants, the tools, procedures, and data analysis that were used in conducting this study. The research design was carefully developed to ensure validity, reliability, and replicability of the results. The use of both quantitative and qualitative methods makes it possible to provide a holistic description of the impact of CPD ITMS on the adoption of innovative teaching practices by mathematics teachers.

2.1. Research Design

This study employed a convergent mixed methods design to capture both the measurable outcomes and lived experiences of teachers and deputy headteachers. The quantitative strand assessed levels of adoption through standardized questionnaires, while the qualitative strand explored perceptions, challenges, and institutional support through interviews and classroom observations. Using mixed methods allowed for triangulation, strengthening the validity and reliability of findings and ensuring that statistical results were complemented by contextual insights.

2.2. Participants

This study was conducted in Ngoma District, Eastern Province of Rwanda, in a rural area where classes were larger in size, ICT facilities, and there were resource constraints. The population of the study was all 30 mathematics teachers who had received ITMS CPD training, using a census sampling technique. Also, 15 deputy headteachers of studies were included using the purposive sampling technique in order to provide supervisory points of view regarding CPD implementation, feedback procedures, and support systems. The age of the teachers in the sample varied from 25 to 52 years, and in terms of gender, the sample consisted of 60% male and 40% female teachers. This diversity provided a rich basis for understanding adoption patterns across different career stages, as shown in Table 1.

Table 1. Population and Sample Distribution

Group Accessible	Population	Sample Size	Sampling Method
Mathematics Teachers	30	30	Census Sampling
Deputy Headteachers	15	15	Purposive Sampling

Source: Researchers, 2025

2.3. Research Instruments

To capture a comprehensive picture of how CPD ITMS was being adopted, the study relied on three complementary tools that worked together rather than in isolation. A structured questionnaire was administered to mathematics teachers, designed to measure confidence, readiness, adoption, and feedback related to innovative teaching methods. The tool had 25 items that were measured using a five-point Likert scale. The tool was adopted from previously validated research on CPD before the tool was refined during the pilot testing stage. The reliability of the tool was demonstrated by its Cronbach's alpha of 0.82.

The semi-structured interview method was used with eight specific questions for each respondent. This interview lasted about forty minutes on average. It is noteworthy that the interviews were held in a face-to-face format, thus providing respondents with an opportunity to think about the impact of CPD ITMS, difficulties with supervision, and the help they get from the institution.

Finally, classroom observations were carried out to verify whether learner-centered strategies were being applied in practice. A structured checklist developed by the researchers guided these observations, focusing on indicators such as group work, ICT integration, inquiry-based learning, and lesson interactivity. Each indicator was assessed on a three-point scale (low, moderate, high), enabling systematic comparison across lessons, consistent with recent Rwandan classroom-observation research (Ndiokubwayo et al., 2020, 2022) and drawing on established professional development evaluation and review frameworks (Kirkpatrick, 1994; Villegas-Reimers, 2003).

By weaving together questionnaires, interviews, and observations, the study achieved methodological triangulation. This integration reduced bias, strengthened credibility, and ensured that statistical findings were enriched by the lived experiences and classroom realities of teachers and supervisors. Table 2 below indicates the instruments used to collect data.

Table 2. Data Collection Instruments

Instrument	Target Group	Purpose
Questionnaire	Mathematics Teachers	Measure adoption of innovative teaching methods
Semi-Structured Interview	Deputy Headteachers	Explore perceptions and supervisory challenges
Classroom Observation	Teachers	Verify the use of learner-centered strategies

Source: Researchers, 2025

2.4. Procedures

The data were collected through a structured method. The questionnaires were given to all the mathematics teachers, while interviews were held with the deputy headteachers after receiving permission from the school administrations. Ethical clearance was acquired from the Research Ethics Committee of the University of Rwanda College of Education, and informed consent was obtained from all participants. In order to ensure the anonymity of the responses, the responses were anonymous, and participation was voluntary.

2.5. Data Analysis

The quantitative data were subjected to coding and analysis using SPSS through descriptive statistics and a one-sample *t*-test to test the level of adoption. The qualitative data from the interviews and observations were analyzed thematically through the use of codes developed inductively to highlight emerging themes such as shortage of resources, mentoring needs, and organizational support. The merging of the quantitative and qualitative strands was guided by Creswell's (2014) framework of mixed methods research.

Table 3. Validity and Reliability Measures

Measure	Description	Outcome
Instrument Validation	Expert review of questionnaires	Achieved
Pilot Testing	Conducted in the neighboring district	Refined
Triangulation	Multiple sources (teachers, heads, observations)	Achieved
Reliability Testing	Cronbach's alpha for questionnaire items	0.82

Source: Researchers, 2025

3. RESULTS

Results are presented separately from the discussion and emphasize the most significant findings. Tables are numbered consecutively in the order they appear, with captions centered above each table. Figures are numbered sequentially, and captions are placed below each figure.

3.1. Demographic Profile of Respondents

The demographic profile of the teachers revealed a balanced distribution across gender, qualifications, and teaching experience. Most participants were male (60%) and held bachelor's degrees (83%), while a smaller proportion were female (40%) or held master's degrees (17%). Teaching experience varied, with roughly one third having less than five years, 40% between five and ten years, and just over a quarter more than ten years. This diversity provided important context for interpreting how CPD ITMS was adopted, as teachers at different career stages brought varied perspectives and capacities into the program.

Table 4. Demographic Profile of Teachers

Variable	Frequency	Percentage
Gender (Male/Female)	18 / 12	60% / 40%
Qualification (Bachelor/Master)	25 / 5	83% / 17%
Teaching Experience (<5 yrs / 5–10 / >10)	10 / 12 / 8	33% / 40% / 27%

Source: Researchers, 2025

3.2. Quantitative Findings

Statistical analysis confirmed that CPD ITMS had a significant effect on teachers' willingness to adopt learner-centered practices, with results showing $t(29) = 4.39$, $p < 0.001$. Teachers reported strong readiness ($M = 4.64$) and high confidence ($M = 4.57$) in applying innovative methods. Skills related to lesson planning and delivery showed moderate improvement ($M = 4.14$), while lesson interactivity was only partially adopted ($M = 3.29$). Application of CPD strategies was inconsistent ($M = 2.62$), and feedback mechanisms were particularly weak ($M = 2.45$), pointing to gaps in institutional support.

Table 5. Summary of Quantitative Findings

Variable	Mean (M)	SD	Interpretation
Adoption of innovative methods	4.64	0.87	Strong readiness
Confidence in learner-centered	4.57	0.91	High confidence
Skills to implement CPD	4.43	0.95	Positive readiness
Lesson planning & delivery	4.14	1.02	Moderate improvement
Lesson interactivity	3.29	1.11	Partial adoption
Application of CPD strategies	2.62	1.06	Inconsistent implementation
Feedback mechanisms	2.45	1.03	Weak institutional support

Source: Researchers, 2025

3.3. Qualitative Findings

The qualitative evidence reinforced these statistical results. Teachers described experimenting with group work, inquiry-based learning, and ICT integration, but classroom observations revealed that such practices were only partially implemented. Large class sizes and limited resources were frequently mentioned as barriers. One teacher explained, "We try group work, but with more than 60 students in a class, it becomes difficult to manage." Another noted, "ICT would help us, but computers are not available in most classrooms."

Deputy headteachers expressed appreciation for CPD ITMS but admitted that their lack of direct training limited their ability to provide effective supervision. As one deputy headteacher remarked, "Without training, it is hard to guide teachers on CPD strategies." This absence of structured mentoring explains the weak feedback mechanisms observed, as teachers lacked consistent guidance to sustain innovation.

4. DISCUSSION

4.1. Interpretation of Findings

The findings of this study demonstrate that CPD ITMS has been effective in strengthening teachers' confidence and readiness to adopt learner-centered practices. High mean scores for confidence and adoption readiness reflect this positive impact. Yet, the translation of readiness into actual classroom practice was only moderate. Teachers often faced constraints such as overcrowded classrooms, limited ICT resources, and insufficient mentoring structures. This gap between what teachers feel prepared to do and what they can realistically implement underscores the critical role of institutional support in sustaining CPD outcomes. Without adequate scaffolding, confidence alone does not guarantee consistent pedagogical innovation.

4.2. Feedback Mechanisms and Institutional Support

A key limitation involves the area of feedback. The deputy headteachers, whose mandate was to monitor teaching practices, did not benefit directly from CPD ITMS training. Thus, they lacked the ability to provide feedback and mentorship to the teachers. This organizational limitation limited the sustainability of the CPD process. This finding supports the teacher change model proposed by Guskey (2002), where it was indicated that for professional development to occur, it requires supportive structures that will support new practices. This is in agreement with the Social Learning Theory by Bandura (1977), where he emphasized that for behavioral changes to occur, one needs feedback and observation.

4.3. Comparison with Global and Regional Evidence

The challenges observed in Rwanda mirror patterns seen globally and regionally. In Japan, lesson study has shown the value of collaborative reflection and structured feedback, while Singapore's CPD frameworks integrate mentoring and ICT to ensure sustained teacher support. Finland's model embeds autonomy and research-based practice, making institutional support integral to professional development. In Africa, Kenya's SMASSE programme and Uganda's peer mentoring initiatives improved teacher competence but struggled with sustainability due to weak institutional structures (Omara et al., 2019; Wabule, 2016). Rwanda's CPD ITMS reflects similar strengths and weaknesses: it builds teacher knowledge and confidence but lacks the institutional scaffolding necessary to sustain adoption, particularly in rural contexts where resource shortages and supervisory gaps are most pronounced.

4.4. Policy Recommendations

The findings of this study suggest several actionable steps for policymakers, district leaders, and school administrators in rural Rwanda. First, mentoring should be institutionalized by training deputy headteachers and senior teachers to act as CPD supervisors, embedding structured feedback loops into everyday school practice. District leaders could also establish CPD learning clusters, enabling teachers to share experiences, observe lessons, and reflect collectively, modeled on Japan's lesson study approach. At the policy level, investment in ICT infrastructure is critical, particularly in rural schools where shortages are most acute. Digital mentoring platforms would allow teachers to access resources, exchange lesson plans, and receive remote feedback, thereby bridging resource gaps. Finally, CPD participation and adoption should be integrated into teacher appraisal and promotion systems, ensuring accountability and motivating teachers to sustain innovative practices. These measures would strengthen the translation of CPD training into consistent classroom practice and create a supportive environment for long-term pedagogical change.

4.5. Impact on Student Learning Outcomes

Although this study focused primarily on teacher adoption, the ultimate goal of CPD ITMS is to improve student learning. Classroom observations indicated that when teachers applied CPD strategies, students became more engaged, collaborated more effectively, and demonstrated stronger problem-solving skills. Learner-centered approaches encouraged active participation and aligned closely with Rwanda's

Competence-Based Curriculum. However, weak feedback mechanisms risked limiting these benefits, as inconsistent mentoring meant that students did not always experience innovative practices. Future research should therefore extend beyond teacher adoption to track student achievement and attitudes, providing a fuller picture of CPD ITMS's long-term impact.

4.6. Contribution to Literature

This study contributes uniquely by shifting the focus from teacher perceptions to actual classroom adoption in rural Rwanda. It highlights the paradox of teachers reporting high confidence yet demonstrating only moderate implementation, and it identifies weak feedback mechanisms as the critical barrier to sustainability. By situating Rwanda's experience within global and regional CPD evidence, the study underscores the importance of institutional support and mentoring in sustaining pedagogical innovation.

Several limitations existed in the current research. First, the study was limited to one district, hence affecting its external validity to other areas. Secondly, the sample size was relatively small (consisting of 30 teachers and 15 deputy headteachers). Although a combination of data collection methods was used (triangulation through classroom observation and self-reporting), the latter might have posed challenges, as self-reported information is often biased. Thirdly, the study did not have a longitudinal component, which would help measure the sustainability of CPD ITMS over time. Consequently, future research needs to involve various districts as well as larger samples. In addition, such studies should have a longitudinal component that will measure both the sustainability of CPD ITMS and its impact on students.

5. CONCLUSION

This current research explores the effects of Continuous Professional Development in Innovative Teaching Methods for Mathematics and Science (CPD ITMS) on the use of learner-centered approaches among mathematics teachers in Ngoma District, Rwanda. Findings reveal a major paradox, as mathematics teachers show high levels of readiness to implement innovations, but their implementation in practice is moderate. Factors that hinder the transformation of training into practice include a high student-teacher ratio, lack of ICT tools, and ineffective mentoring systems. Besides, another weakness within the institutions was revealed; namely, deputy headteachers, who monitor the implementation of instruction, do not directly benefit from CPD ITMS.

The importance of this study lies in the focus it places on adoption as opposed to perception. This is because it illustrates how confidence alone is not enough to make sure there is pedagogical change without systemic backing. Placing the experience of Rwanda in the context of CPD worldwide and regionally helps to show the importance of mentorship and supervision, among others.

Some limitations need to be addressed. First, the study is limited to one rural district only, limiting the generalization of the findings to other areas. Also, the sample size is quite small, and the reliance on self-reporting data, even though coupled with classroom observation, may lead to bias. In addition, the failure to include the longitudinal element of the study makes it difficult to evaluate the sustainability of CPD effects in the long run. Further studies need to be conducted in several districts using large samples and a longitudinal design.

Based on this evidence, the study suggests that the institutionalization of mentoring be carried out by training deputy headteachers to act as CPD supervisors, and the provision of funds for ICT and classroom materials that will help in the consistent implementation of the strategy. The study also suggests institutionalization of the CPD ITMS in school evaluation and career structures. Overall, this will contribute to accountability and address institutional gaps, ensuring that the CPD training translates to classroom practices.

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Research Ethics. This study received University of Rwanda, College of Education ethics approval on March 12, 2025 (reference number: UR CE/REC/2025/011). The study was conducted in accordance with the ethical principles of the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all participants.

Data Availability Statement. Data can be obtained from the corresponding author on reasonable request, subject to confidentiality agreements with the participating schools.

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Author Contributions. Kubwimana: Conceptualization, methodology, investigation, formal analysis, writing - original draft. Nzabalinwa: Conceptualization, supervision, writing - review & editing.

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