International Journal of Learning, Teaching and Educational Research
Vol. 24, No. 11, pp. 161-184, November 2025
https://doi.org/10.26803/ijlter.24.11.8
Received Aug 13, 2025; Revised Oct 3, 2025; Accepted Oct 17, 2025

Exploring Continuing Professional Teacher Development for Mathematics Teachers in South Africa: Needs, Providers, and Implications for Skills Planning

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Abstract. In South Africa, mathematics education faces challenges due to curriculum changes, technology integration, and pedagogical gaps, necessitating effective continuing professional teacher development (CPTD) for teachers. This study explores mechanisms for identifying the CPTD needs of mathematics teachers and key role players/providers, identifying misalignments in the system to enhance teaching quality and student outcomes. This study adopted a qualitative interpretivist paradigm with a phenomenological design. Data were collected through semi-structured interviews with 29 departmental officials representing nine provinces, the Department of Basic Education, the Department of Higher Education and Training, and the South African Council for Educators. Thematic analysis, guided by Braun and Clarke's (2006) six-step approach, was applied to the interview transcripts to identify recurring patterns and key themes related to teachers' professional development needs and the roles of CPTD providers. Framed by Wenger's social learning theory and Shulman's pedagogical content knowledge framework, unreactive approaches and resource strains were identified, implying needs for proactive skills planning. The findings revealed that CPTD needs are identified through learner performance analysis, teacher feedback through pre/post-tests, and provincial curriculum priorities focusing on topics like trigonometry and Euclidean geometry. CPTD providers included provincial education departments, national education bodies, universities, non-governmental organisations, and associations, like the Association for Mathematics Education of South Africa, with collaborative yet inconsistent structures leading to uneven provision. The findings of this study can be used to inform policy reforms designed to bridge gaps and foster collaborative mathematics development, ultimately advancing equity in mathematics education and South Africa's economic goals. In conclusion, an integrated national CPTD framework is essential for equitable professional growth.

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Keywords: Skills planning; CPTD; subject knowledge; teachers' needs; professional growth

1. Introduction

Mathematics education plays an important role in developing learners' critical thinking and problem-solving skills, which are vital for navigating the complexities of the 21st century (Luneta, 2022). In South Africa, the quality of mathematics teaching is heavily dependent on the professional development of teachers. Continuing professional teacher development (CPTD) serves as a critical mechanism to enhance teachers' pedagogical skills, subject knowledge, and ability to adapt to evolving educational demands (Njenga, 2022).

The rapid pace of curriculum changes and the increasing integration of technology into the classroom require continuous development of teachers' competencies to ensure that they are equipped to use these technologies effectively (Mdhlalose & Mlambo, 2023). However, implementing effective CPTD for mathematics teachers presents several challenges. These include accurately identifying teachers' professional needs and clarifying the roles of various CPTD providers (Mwila et al., 2022).

Globally, there appears to be a gap between the identified professional development needs of teachers and the training provided, which may limit the impact on teaching quality (Cassity & Wong, 2022; Wei et al., 2022). Additionally, the roles and contributions of various providers, such as government bodies, NGOs, and universities, are not always clearly defined, potentially leading to fragmented efforts (Cassity & Wong, 2022). Furthermore, teachers' CPTD needs and the provision of CPTD are not well understood, which may result in programs that fail to address level-specific challenges (Wei et al., 2022).

Furthermore, the effectiveness of CPTD for mathematics teachers in South Africa may be hindered by potential misalignments and inefficiencies within the system, leading to inequities. Budget constraints and rural-urban disparities further hinder effectiveness, especially in under-resourced schools (Van Der Merwe-Muller & Dasoo, 2021; Nhlumayo & Chikoko, 2022). These issues may impede teachers' professional growth, ultimately affecting student learning outcomes in mathematics, a subject critical to South Africa's educational and economic goals (Tibane et al., 2024).

Although professional development is recognised (Masha et al., 2025) as essential for improving mathematics teaching, the literature presents a fragmented picture, with research either focusing on general teacher development or limited to specific provinces and few studies examining the national, data-driven mechanisms that are used to identify mathematics teachers' needs. This study addresses this gap in the literature regarding how mathematics teachers' CPTD needs are identified and how the various providers, government departments, universities, NGOs, and professional associations coordinate their roles to deliver CPTD in the South African context. By exploring these mechanisms and mapping the relationships between key role players across all nine provinces, this study

contributes new knowledge to enable CPTD to be planned and implemented more systematically and equitably to improve teaching quality and learner outcomes in mathematics.

The aim of this study was to identify national and provincial players that provide CPTD to South African mathematics teachers and identify the mechanisms they use to assess the professional development needs of these teachers. To achieve this aim, the study addressed the following two research questions:

1. How are the needs of mathematics teachers identified in relation to Continuing Professional Teacher Development (CPTD)?
2. Who are the role players and providers of CPTD for mathematics teachers in South Africa?

2. Literature Review

This section reviews the scholarly perspectives that informed this study of continuing professional teacher development (CPTD) for mathematics teachers in South Africa.

2.1 Identification of Needs

2.1.1 Curriculum updates and changes

Mathematics curricula worldwide have undergone significant changes in recent years in response to societal needs, technological advancements, and educational research. Early curricula were typically narrow, focusing on arithmetic, algebra, and geometry; over time, there has been a shift toward broader content, the inclusion of real-world applications, and the integration of computational thinking and technology (Rafiepour & Farsani, 2021).

In South Africa, the education system in place during the apartheid era enforced racial segregation and provided inferior education to Black South Africans, exacerbating socioeconomic disparities. Following the end of apartheid in 1994, the South African mathematics curriculum was transformed from a traditional, content-heavy curriculum to an outcomes-based education (OBE) model that aimed to promote equity, social justice, and democratic values in line with the country's political transformation (Jojo, 2019). The OBE curriculum emphasized learner-centeredness, continuous assessment, integration of knowledge, and the development of critical and creative thinking skills.

However, challenges arose in its implementation due to issues of clarity, lack of teacher preparedness, and resource disparities. This led to further revision of the curriculum through the National Curriculum Statement (NCS) and the Curriculum Assessment Policy Statements (CAPS) (Cross et al., 2002), which aimed to ensure a structured and accessible curriculum with standardization and clear assessment criteria. Though CAPS represents progress towards educational equity, its effectiveness has been hindered by ongoing socioeconomic challenges and the legacy of apartheid, including unequal resources and teacher capacity issues (McKeever, 2017; Mpungose, 2020).

Thus, while there have been efforts towards decolonizing the curriculum, addressing historical inequalities, and ensuring the curriculum is responsive to South Africa's unique social and economic challenges (Blignaut, 2020; Mbhiza & Jojo, 2024), issues such as teacher preparedness, resource disparities, and persistent performance gaps remain significant challenges for meaningful transformation in mathematics education (Blignaut, 2020; Mbhiza & Jojo, 2024).

In this context, professional development plays a crucial role in ensuring that teachers are equipped to implement revisions to the curriculum—particularly in a field as dynamic as mathematics education (Luneta, 2022). CPTD promotes coherence and relevance in the mathematics classroom by ensuing that teachers are equipped with the pedagogical strategies required to enact the evolving requirements of the curriculum (Luneta, 2022; Mwila et al., 2022).

2.1.2 Integration of technology into education

The integration of technology into teaching and learning holds the potential is a key competency students require to be adequately prepared for the digital demands of the twenty-first century (Mdhlalose & Mlambo, 2023; Whitney-Smith et al., 2022). Research indicates that the integration of technology into mathematics education can enhance student engagement and learning outcomes (Muyco, 2025; Serin, 2023).

As technology becomes increasingly integral to education, teachers need ongoing support to navigate this rapidly evolving landscape. Mathematics teachers require CPTD to enhance their digital literacy skills and learn how to implement educational technologies effectively in the classroom. CPTD can provide teachers with opportunities to investigate how to incorporate cutting-edge technologies, internet resources, instructional software, and digital resources into their lesson plans (Luneta, 2022; Mwila et al., 2022).

Furthermore, the rapid evolution of AI-based tools like ChatGPT calls for professional development that equips teachers with critical digital literacy and evaluative skills (Ampo et al., 2025a). Thus, CPTD is required to build both technological and pedagogical competences. Research on blended learning highlights the persistent digital divide and the need for infrastructure and teacher support in resource-constrained contexts (Ampo et al., 2025). This reinforces the call for CPTD programmes that build technological resilience across South Africa's provinces.

2.1.3 Pedagogical strategies and assessment practices

Effective mathematics teaching demands more than content expertise—it requires well-developed pedagogical skills and robust approaches to assessment and feedback (Vale & Graven, 2023). CPTD plays a crucial role in equipping teachers with these capacities. By engaging in CPTD, mathematics teachers are exposed to a range of innovative instructional strategies that move beyond traditional lecture-based delivery. These include differentiated instruction, inquiry-based learning, active and collaborative teaching techniques, and other methods that accommodate diverse learning styles (Vale & Graven, 2023). Such strategies enable teachers to communicate complex mathematical concepts, such as

algebraic reasoning or Euclidean geometry, more effectively and to stimulate deeper learner engagement and understanding (Galope & Gumanoy, 2025; Hunter et al., 2016). Dialogic approaches, such as the Socratic seminar, demonstrate how structured dialogue can foster critical engagement and deeper comprehension in higher education (Saksono et al., 2025). This underscores the value of discussion-oriented CPTD programmes for mathematics teachers seeking to strengthen reasoning and problem-solving skills.

Evidence from multimodal instructional techniques used by teachers—which integrate visual, auditory, and hands-on methods—shows significant gains in conceptual understanding and retention (Tetteh et al., 2025). Similar approaches could strengthen mathematics CPTD by encouraging varied, learner-centered strategies. Equally important is the development of assessment and feedback practices that inform teaching and promote meaningful learning. Modern mathematics education emphasises formative assessment—continuous assessment of understanding through questioning, tasks, and learner reflection—complemented by summative evaluation.

CPTD can guide teachers to design assessment instruments aligned with curriculum standards and to use diagnostic tools to identify misconceptions early (Niyibizi & Mutarutinya, 2024; Niyibizi & Mutarutinya, 2024). Training in constructive feedback techniques helps teachers not only to measure achievement but also to support individual learners' progress and build their confidence (Pongračić et al., 2022; Stovner & Klette, 2022). For teachers to be able to integrate these practices into their repertoire of strategies and use them effectively, they need sustained professional development paired with implementation support, rather than isolated workshops (Mahlambi et al., 2023). Together, advanced pedagogical strategies and sound assessment practices enable teachers to create responsive classrooms where instruction is adapted based on evidence of learners' understanding.

While digital tools offer powerful possibilities for education, their impact ultimately depends on teachers' abilities to integrate them within sound pedagogical strategies and assessment practices. Technology cannot take the place of robust pedagogy; instead, it can amplify the effectiveness of teaching when underpinned by strong instructional design and responsive assessment practices (Nguyen & Habók, 2023). Thus, it is essential that CPTD builds teachers' pedagogical and assessment capacities as well as their digital competences.

2.1.4 Deepening mathematical content knowledge

Alongside strong pedagogy and assessment skills, mathematics teachers must continually upgrade their specialised subject knowledge. Mathematics is not static: new curriculum emphases, advances in mathematical applications, and changing societal needs regularly reshape what teachers are expected to teach. In South Africa, for example, curriculum reform has resulted in probability being introduced earlier in the curriculum and a renewed emphasis on functions and trigonometry, requiring teachers to master content they may not have encountered in their own schooling or tertiary training (Masha et al., 2025). CPTD

programmes that focus on deepening conceptual understanding and addressing typical learner misconceptions are therefore indispensable.

Developing rich content knowledge allows teachers to present mathematics as a connected, logical discipline rather than as a set of isolated procedures (Asaba, 2023). It equips them to anticipate where learners are likely to struggle, to explain concepts using multiple representations, and to integrate real-life contexts and technology meaningfully (Asaba, 2023; Copur-Gencturk & Tolar, 2022).

Additionally, sustained professional learning through advanced courses, collaborative lesson study, or partnerships with universities and professional associations ensures that teachers remain confident and authoritative in their classrooms (Jeschke et al., 2021). In turn, strong, integrated subject knowledge underpins the effective use of innovative pedagogies and high-quality assessment, creating a virtuous cycle of professional growth and improved learner outcomes.

2.2 Key Role Players and Providers of CPTD for Mathematics Teachers in South Africa

The effective implementation of CPTD for mathematics teachers in South Africa relies on the collective efforts of a network of diverse stakeholders that play complementary roles in the design and delivery of professional learning opportunities. At the centre of this network is the Department of Basic Education (DBE), which is primarily responsible for designing and implementing national education policies and programmes aimed at improving the quality of teaching. Government-led CPTD initiatives coordinated by the DBE ensure policy alignment and consistency, and research demonstrates that such state-driven programmes are critical for sustaining long-term improvements in teaching practices and learner outcomes (Tibane et al., 2024; Ventista & Brown, 2023).

Supporting—and sometimes challenging—government efforts are teacher unions, which advocate for their members' professional growth and negotiate for better working conditions (Niu, 2025). By organising workshops, facilitating peer networks, and lobbying for professional development opportunities, teacher unions ensure that teachers' voices are represented in CPTD policy and practice. Studies confirm that unions are vital partners in professional development, helping to secure resources and create conditions conducive to continuous learning (Elias & Iramba, 2022; Khanal, 2021; Lyon, 2022).

Alongside these national actors, local and international non-governmental organisations (NGOs) bring specialised expertise, innovative approaches, and additional resources to mathematics CPTD. NGOs often partner with schools, provinces, and universities to deliver targeted interventions, pilot new methodologies, and address gaps that government programmes alone may not fill. Evidence shows that NGOs enrich the professional landscape through their flexible, needs-driven strategies and their ability to introduce global best practices into local contexts (Abiddin et al., 2022; Jacob et al., 2017).

Universities and colleges also play a central role, not only through formal qualifications such as postgraduate degrees, but also by designing and delivering short courses, workshops, and collaborative research projects. Higher education institutions contribute specialised subject and pedagogical expertise, bridging theory and classroom practice, and research highlights their unique capacity to foster deep, sustained professional learning for mathematics educators (Chikola et al., 2025; Li, 2022).

In addition, professional associations—notably, the Association for Mathematics Education of South Africa (AMESA) and the South African Council of Educators (SACE)—strengthen CPTD by creating professional communities of practice. These associations organise conferences, publish resources, and facilitate peer-to-peer knowledge exchange. They foster a culture of professional dialogue and shared problem-solving that extends learning beyond formal training events—a role widely recognised as critical to raising the quality of mathematics teaching (Chikola et al., 2025; Gamba & Deri, 2023; Sowndappan, 2023). These findings support the need for a coordinated national CPTD framework that also addresses teachers' well-being and work environment.

Despite the strong presence of these role players, important challenges remain. Existing studies on mathematics CPTD in South Africa tend to be localised or theoretical, rarely exploring the data-driven mechanisms by which teacher development needs are identified at the national level or the collaborative interplay among these stakeholders (Masha et al., 2025). This gap means that opportunities for alignment and systematic skills planning are often missed.

Although recent literature calls for responsive, pedagogical content knowledge (PCK)-enhanced programmes that integrate technology and collaboration, comprehensive evidence on how different providers coordinate their efforts is limited. Addressing these knowledge gaps is therefore essential. By investigating how needs are identified across provinces and how key actors interact, this study generated actionable insights that can inform more coherent, equitable CPTD policies and, ultimately, strengthen mathematics teaching and learning outcomes in South Africa.

3. Theoretical Framework

The study sought to understand how teachers' professional needs are identified and to identify the key role players and providers in the provision of CPTD in South Africa. Wenger's social learning theory grounded the study, supplemented by Shulman's construct of pedagogical content knowledge. This framework offered a comprehensive approach to understanding how mathematics teachers learn and develop professionally within their unique educational contexts.

Wenger's social learning theory—often called 'communities of practice' (CoP) theory—suggests that learning is fundamentally a social process that occurs through participation in shared practices within a community, involving active engagement with others (Farnsworth et al., 2016; Smith, 2006; Smith et al., 2017). Wenger's theory is relevant to this study as teachers often develop professionally

through communities of practice that are constituted as workshops, peer collaboration, professional associations, or school-based initiatives. Wenger's social learning theory frames the research questions related to identifying teachers' professional needs and the role players and providers involved with the provision of CPTD. In South Africa, the National Policy Framework for Teacher Education and Development structures individual teacher development using a system of professional development points (Smith, 2006).

Wenger's framework offers several advantages as a theoretical lens. It emphasises the social and collaborative nature of learning and can be used flexibly when analysing different educational contexts. However, it does not fully engage with the subject-specific aspects of this study, such as pedagogical content knowledge for teaching algebra or geometry. Shulman's construct of pedagogical content knowledge (PCK) complemented Wenger's social learning theory in this study by addressing the subject-specific aspects of CPTD that were key to this study.

Shulman's concept of pedagogical content knowledge (PCK) suggests that effective teaching requires more than just mastery of subject matter (content knowledge, 'CK') or general teaching skills (pedagogical knowledge, 'PK'): it requires a unique blend of both, specifically tailored to making subject matter understandable to students (Depaepe et al., 2013; Driel & Berry, 2017; Star, 2023). In this study, PCK guided the identification of teachers' needs by focusing on gaps in their ability to teach specific mathematical concepts or use effective pedagogical strategies. It also highlighted the importance of providers like universities and professional associations that offer specialized training in mathematics pedagogy.

In the South African context, incorporating PCK could help teachers develop strategies to teach complex mathematical concepts effectively, addressing the unique challenges of teaching mathematics. While PCK provides a subject-specific lens, it is less focused on the social and collaborative aspects of professional development, making it a valuable, but secondary, element of the theoretical framework. The integration of Wenger's social learning theory and Shulman's PCK brought together the social context of learning with the subject-specific knowledge required for effective teaching. Table 1 illustrates how social learning theory and PCK relate to the study's research questions.

Table 1: Relationship of theoretical framework to research questions

Research Question	Wenger's Social Learning Theory	Shulman's PCK
How are the needs of mathematics teachers identified?	Needs identified through participation in CoPs, through discussions and shared experiences.	Needs identified by gaps in CK, PK, and PCK, such as curriculum alignment or student misconceptions.
Who are the role players and providers of CPTD?	CoPs include DBE, teacher unions, NGOs, universities, and associations like AMESA, fostering collaboration.	Providers offer subject-specific training, enhancing PCK through workshops on mathematics pedagogy.

The integration of these two lenses suggests that CoPs provide the environment in which teachers develop their PCK. For example, in a CoP, mathematics teachers might engage in discussion about how to teach Euclidian geometry, share a repertoire of lesson plans, and work toward improving student outcomes (joint enterprise), thereby enhancing their PCK. This dynamic interaction is crucial for CPTD, as it aligns with the study's focus on collaborative and subject-specific development.

4. Methodology

This study adopted a qualitative approach within an interpretivist paradigm to investigate the continuing professional teacher development (CPTD) needs of mathematics teachers in South Africa and identify the role players and providers involved. The interpretivist paradigm was selected as it seeks to understand participants' subjective experiences and perspectives (Creswell & Poth, 2016), aligning with the study's aim. This paradigm supports the use of qualitative methods, which were used in this study to capture rich, contextual data. A phenomenological research design was adopted.

Phenomenological research design is a qualitative approach focused on exploring and interpreting the lived experiences of individuals to uncover the meanings they ascribe to specific phenomena (Neubauer et al., 2019). It involves gathering detailed descriptions of participants' experiences—often through interviews or narratives—and analysing these to uncover the core meanings or essences of the phenomena under study (Knaack, 1984; Neubauer et al., 2019).

Hence, a phenomenological research design was adopted because the study aimed to gain an in-depth understanding of how mathematics teachers' professional development needs are identified and how key role players and providers operate within the CPTD system. This orientation aligns with the study's qualitative interpretivist paradigm, enabling the researchers to capture rich, first-hand accounts of mechanisms, challenges, and collaborative practices that could not be fully understood using quantitative or purely descriptive approaches.

The study focused on the education departments of all nine South African provinces, the national Department of Basic Education (DBE), the Department of Higher Education and Training (DHET), and the South African Council for Educators (SACE). Purposive and convenience sampling approaches were used to select participants who could provide diverse provincial and national perspectives on mathematics CPTD. Provincial heads of mathematics or officials directly involved in teacher professional development were approached based on their roles and availability, ensuring that participants were well-positioned to provide first-hand insights into needs-identification processes and the coordination of CPTD provision.

This distribution allowed for both national-level policy perspectives and regionally specific implementation insights, ensuring a balanced and comprehensive understanding of the mechanisms and challenges shaping

mathematics teacher development across South Africa. This method was determined to be appropriate given the logistical challenges of accessing busy departmental officials and the need for voluntary participation to ensure ethical compliance. The sample size was determined through data saturation: additional participants were selected until interviews no longer produced new themes or insights, as similar patterns and perspectives consistently emerged across provinces and national bodies, indicating that the core categories had been fully explored.

Twenty-nine departmental officials involved in mathematics education participated in the study. From the Department of Basic Education (DBE), nine officials were included; all were based in the province of Gauteng and were directly responsible for mathematics teacher development at national or provincial levels. Three participants who oversaw teacher education and professional learning programmes were selected from the Department of Higher Education and Training (DHET). Representation from provincial education departments included Free State (2), Limpopo (2), Mpumalanga (2), KwaZulu-Natal (2), Eastern Cape (3), Northern Cape (3), Western Cape (1), and Northwest (1). To incorporate professional regulation and accreditation perspectives, one official from the South African Council for Educators (SACE) was included.

Data were collected through semi-structured interviews, guided by a schedule designed to explore CPTD needs and identify providers. This method allows for participants to be probed for insights while maintaining focus on the research questions (Kallio et al., 2016). Interviews were recorded with the consent of participants and transcribed verbatim for analysis. Thematic analysis was conducted using Braun and Clarke's (2006) six steps, which enabled the systematic exploration of patterns related to teachers' CPTD needs and stakeholder roles, ensuring alignment with the study's objectives. The application of Braun and Clarke's (2006) six steps in this study is described in Table 2, below:

Table 2: Application of Braun and Clarke's (2006) six-step thematic analysis

Braun & Clarke's (2006) six steps	Application in this study
1. Familiarize yourself with the data	The researchers transcribed the semi-structured interviews verbatim and immersed themselves in the data by repeatedly reading the transcripts to gain a deep understanding.
2. Generate initial codes	Initial codes were generated by identifying recurring elements in the transcripts, such as references to "*learner performance analysis*," "*pre- and post-tests*," "*curriculum priorities like trigonometry and geometry*".
3. Search for themes	Codes were grouped into broader themes, such as "*Identification of CPTD Needs*" (encompassing sub-themes like learner performance analysis, teacher feedback, and curriculum priorities) and "*Role Players and Providers*".
4. Review themes	Themes were reviewed against the coded data and full transcripts to verify coherence; for instance, ensuring

	sub-themes under CPTD needs accurately reflected provincial variations in performance tracking.
5. Define and name themes	Themes were defined and named to capture the essence of the findings, such as "*Learner Performance Analysis*" for data-driven needs identification, and "*Provincial Education Departments*."
6. Produce a report	The report was produced by integrating verbatim participant quotes into the findings section, linking themes to the research questions (e.g., how needs are identified and who the providers are), and discussing implications in light of the literature and theoretical frameworks, with recommendations for skills planning.

Given the qualitative and interpretivist nature of this study, multiple strategies were applied to enhance credibility and trustworthiness. Credibility was strengthened through member checking, where key participants were provided with summaries of their interview transcripts to confirm the accuracy of their views and clarify ambiguities. Triangulation was achieved by drawing data from a wide range of stakeholders across all nine provinces and from national bodies (DBE, DHET, and SACE), allowing for the comparison of perspectives and the identification of converging patterns.

Dependability was promoted through a detailed audit trail, including a transparent record of the research process, interview protocols, coding framework, and decision-making steps during thematic analysis, enabling other researchers to trace how conclusions were reached. Confirmability was ensured by maintaining reflexive field notes and memos to bracket researcher assumptions and by having the coding process independently reviewed by a second qualitative researcher. Finally, transferability was supported through thick, rich descriptions of the context, participants, and procedures, enabling readers to assess the applicability of the findings to other educational settings.

Ethical considerations were prioritized to protect participants and ensure research integrity. Ethics approval was obtained from the university's Ethics Committee after submission of an application form, research proposal, data collection instruments, and consent forms. Full approval was conditional until written approval was granted by all stakeholders—DBE, DHET, SACE, and all nine provincial education departments—and submitted to the Ethics Committee. Data collection commenced only after full ethics approval, ensuring participant confidentiality, voluntary participation, and informed consent.

5. Results

This section presents the findings of the study on continuing professional teacher development (CPTD) for mathematics teachers in South Africa, addressing the three research questions. The findings were derived from semi-structured interviews conducted with officials and analysed using thematic analysis; they are presented using participants' verbatim responses.

5.1 Mechanism for Identifying the Needs of Mathematics Teachers for CPTD

The mechanism used in the identification of mathematics teachers' CPTD needs in South Africa as shown above involves multiple methods tailored to provincial and national contexts.

5.1.1 Analysis of learners' performance

Participant 1 indicated that the needs were tied to "*FET. Grade 12 performance focus*". Participant 3 indicated that they used results analysis and diagnostic assessment:

> *"We look at the leaner performance and analysis, then do training based on the schools that performed below a certain percentage. Results analysis also form part of the tracking process, quarterly results analysis. A diagnostic is done to find where there is a need, then the CPTD activities will be focused on the identified needs."*

Participant 11 described a similar approach:

> *"The province holds quarterly review sessions, which are held by the circuit coordination, together with the district and the curriculum unit attends the sessions. In these sessions, learner performance is highlighted, and based on the review session, it is clear that the improvement of learner performance is not much – as the result of the learners is poor. Despite the workshops being conducted, the performance is still poor because of the limited time in which these workshops take place."*

5.1.2 Tracking needs and outcomes

Teachers' needs emerged from direct input, though specific mechanisms varied. Participant 3 indicated that pre-test and post-test upon arrival at workshops helped track needs and outcomes:

> *"Upon arrival, they will write a pre-test, and after that they will write a post test. From there – remember that now we have got the list of the schools whereby now the subject advisors, together with the coordinators, will make follow-ups to those schools/teachers who were trained."*

Participant 2 noted that they did track needs and outcomes following CPTD. They noted:

> *"Yes, the department does monitor the performance of learners. But what we have identified is that learners are still struggling with these topics due to a lack of confidence from the teachers with regards to these topics, which affect learners' performance. But from my observations, teachers are starting to gain more confidence as a result of workshops in this topic."*

Similarly, Participant 8 highlighted post assessment and indicated that:

> *"Yes, the Department always analyse learner performance on topics that teachers were trained on. Always, the analysis will show improvement. However, in almost all programmes, always a need for more support during implementation is identified."*

5.1.3 Curriculum areas prioritized by provincial departments for CPTD

Most provinces seemed to focus on similar topics. Participant 7 indicated that "*in most cases, our teachers are struggling with trigonometry, Euclidean geometry*". Participant 6 mentioned these topics, as well as "*functions and algebra*". Participant 11 said that:

> *"The topics that are covered are the topics that are currently being covered at schools for that term, as per the requirements of the annual teaching plan. That is why the workshops are conducted each term – to cover all the topics covered in each term. For example, in FET: in Term 1 we cover trigonometry, in Term 2 we cover Euclidian geometry. And then we cover data handling and probability – but we lean more towards probability as compared to data handling, as the probability is more challenging to learners compared to data handling."*

Participants 15 and 17 made statements that supported this. Participant 15 said:

> "*For the GET, we mostly focus on algebra, geometry and graphs, as these topics also continue to the FET – to prepare learners for FET with good mathematical content knowledge*".

Participant 17 said:

> "*Paper 2 is much more problematic as compared to Paper 1, because the topics in Paper 2 the teachers were not trained to teach – and they also did not do that content in high school, as it was part of Paper 3 previously and learners would choose to do it or not – which has a huge impact on the teachers who should now be responsible for teaching them. Such topics are geometry and trigonometry. So more training is required in Paper 2."*

These mechanisms demonstrate that CPTD needs are not identified in isolation but are systematically tracked through learner outcomes, teacher performance, and curriculum priorities, thereby fulfilling the purpose of section 5.1 in showing how needs are surfaced, monitored, and addressed in practice.

5.2 Identifying the Role Players and Providers of CPTD for Mathematics Teachers in South Africa

In South Africa, the delivery of CPTD involves a collaborative network of provincial, national, and private stakeholders, as highlighted by participants from various provinces.

5.2.1 Provincial education departments

Participant 5 noted that:

> "*CPTD falls under the curriculum section. The teacher development section provides funding to the curriculum to carry out the training and workshops, which are carried out by the subject advisors. Teacher development is handled by subject advisors without a certain institution that does the training, which puts a strain on the subject advisors as there is little to no manpower. A minimum of 2 to 3 times a year – depending on the availability of funds provided for teacher development."*

In contrast, Participant 22 indicated that there were two main providers that catered for different professional development needs:

> *"Cape Teaching and Leadership Institute (CTLI) is the main provider of Senior Phase CPTD training, supported by subject advisors focusing on Grade 8 and 9, which usually starts in Term 2 . … We also have a boarding programme that is limited to only board teachers."*

Participant 3 indicated that:

> *"Teacher development is a directorate on its own, with MST – as a sub-directorate – organizing training twice in a year – where it would be three days in the first term, and maybe three days in the third term."*

Participant 13 highlighted delegation of duty: *"The Educator Provisional Development (EPD) unit delegates to districts, with HR and teaching development section coordinating university partnerships"*.

5.2.2 National bodies, service providers and selection criteria

Participant 24 indicated that the Department of Basic Education (DBE) collaborated with SACE and provinces:

> *"We don't necessarily work or have service providers, but we work with the national DBE and curriculum unit, making use of various subject advisors/heads from various districts and sometimes other provinces."*

Participant 16 mentioned collaborating with the Department of Higher Education and Training (DHET):

> *"Basically, when it comes to the mathematical side, we have a project named TLDCIP (-Teaching and Learning Development Capacity Improvement Programme-) which is an EU funded. It's a fund of 200 million; it was that amount in 2016 when it started. We have a project called Primary Teacher Education which is developing material to enhance the primary education initial programmes."*

Another collaborative stakeholder was the South African Council for Educators (SACE). Participant 9 indicated that SACE:

> *"Manages teacher professionalisation and ensures all programmes that are meant to capacitate teachers with CPTD must be endorsed by SACE, monitoring through monitoring report post-endorsement."*

In addition to the national bodies, participants mentioned that service providers such as universities and other private entities worked with the provinces, DBE, and SACE. Participant 5 indicated that they "*work in partnership with the University of the Free State for Bloemfontein. For areas in QwaQwa, we work in partnership with TMED; we also have a private project called the Kutlwano Maths and Science Project*".

Participant 22 worked with universities such as "*University of Cape Town (-UCT-) and Stellenbosch University for CTLI materials and University of Witwatersrand for training fifty mathematics teachers with Capitec Foundation sponsorship*". Participant 16 indicated that they had "*working groups that focus on mathematics, with past*

projects like inclusive education through the University of Witwatersrand (WITS), University of Pretoria (UP) and University of Johannesburg (UJ)".

In terms of criteria that private providers were required to meet in order to provide CPTD trainings, some participants indicated that their province did not have selection criteria. Participant 19 described an informal process of simply assessing the value any potential provider might offer:

> *"We don't have criteria to select who we work with as we appreciate any assistance that we receive. But I can say that when a person or a provider approaches us, we look at the personal profile of the provider and they extra knowledge that they might offer."*

Participant 9 indicated that while they did not have preferred service providers, they did have criteria providers must meet:

> *"SACE do not have a preference when it comes to identifying service providers – as long as the service provider meets the requirements in terms of the criteria and is fit for purpose. … There is an international call for the role of CPTD, and this is in line with the Sustainable Development Goals Number 4."*

Participant 12 reported that their province had set criteria and followed a tender process:

> *"Usually, such kind of training is done through teacher development, where they would sit down with the service provider. I think there is criteria with which such providers should meet – you need to be knowledgeable of CAPS. We work on these things, to say, 'We want 1,2,3,4,' and we put it on tender. You cannot just come directly and say, 'I want to train'. Then we advertise, they compete, and the one who meets the requirement will definitely get the job, through our supply chain processes."*

These findings collectively illustrate a multifaceted CPTD landscape in South Africa, where data-driven needs identification and collaborative stakeholder involvement offer promising foundations for supporting mathematics teachers, though variations across provinces suggest opportunities for greater standardization and integration to maximize impact, as discussed below.

6. Discussion

The findings of this study illuminate the mechanisms used to identify continuing professional teacher development (CPTD) needs among mathematics teachers in South Africa and the key role players and providers involved. Guided by Wenger's social learning theory (Farnsworth et al., 2016; Smith, 2006; Smith et al., 2017) and Shulman's pedagogical content knowledge (PCK) (Depaepe et al., 2013; Driel & Berry, 2017; Star, 2023), this discussion engages with participants' statements to unpack their implications for educational practice, scholarly discourse, theoretical alignment, skills planning, and actionable recommendations.

This analysis addresses the study's research questions by examining the main themes arising from the findings: analysis of learners' performance, tracking needs and outcomes, provincial curriculum priorities, provincial education departments, and national bodies with service providers and selection criteria.

6.1 Mechanisms for Identifying CPTD Needs of Mathematics Teachers
This section discusses the following three themes, addressing research question 1: analysis of learners' performance, tracking needs and outcomes, and provincial curriculum priorities.

6.1.1 Analysis of learners' performance
Participants emphasized that CPTD needs are identified primarily by analysing learners' performance through diagnostic assessments and quarterly reviews tied to Grade 12 results. This approach highlights a data-driven strategy where underperformance in specific schools or topics triggers targeted training.

In terms of educational issues, this method underscores the reactive nature of CPTD in addressing systemic gaps in mathematics education, where poor learner outcomes reflect broader challenges like inadequate teacher preparation for curriculum demands (Luneta, 2022; Mwila et al., 2022). It points to the urgency of linking professional development directly to student achievement, preventing persistent low performance in a subject critical to South Africa's economic goals (Njenga, 2022).

This emphasis on performance-based needs identification aligns with the findings of other scholars; for instance, Niyibizi and Mutarutinya (2024) agree that diagnostic assessments are essential for refining instructional decisions, while Stovner and Klette (2022) support quarterly reviews to guide feedback. However, Pongračić et al. (2022) disagree on the sufficiency of short-term workshops, arguing that limited session durations fail to yield sustained improvements, echoing concerns about fragmented CPD efforts (Cassity & Wong, 2022).

Relating these findings to the theoretical framework, this practice resonates with Wenger's social learning theory by fostering communities of practice (CoPs) during review sessions involving circuits, districts, and curriculum units, where sharing of experiences enables stakeholders to identify needs collaboratively (Farnsworth et al., 2016). It also aligns with Shulman's PCK, as performance gaps reveal deficiencies in teachers' abilities to address students' misconceptions in mathematics (Depaepe et al., 2013; Star, 2023).

For skills planning, this implies a need for integrated national databases to track learner data provincially, enabling proactive resource allocation and avoiding siloed responses that exacerbate inequalities across provinces. These insights indicate that while performance analysis is a valuable starting point, its reactive focus limits its long-term impact. We recommend that mandating longitudinal tracking systems with extended workshop durations (at least multi-day sessions per term) and integrating predictive analytics to anticipate needs, ensuring CPTD evolves from playing a remedial role to a preventive role.

6.1.2 Tracking needs and outcomes

Participants described tracking mechanisms like pre-, and post-tests administered during workshops followed by school follow-ups to assess the effectiveness of CPTD. In terms of education, this reveals a commitment to accountability in CPTD, addresses issues like teachers' lack of confidence that have been found to hinder mathematics instruction, and highlights the broader challenge of translating workshop gains into classroom practice, where implementation support is often lacking, potentially perpetuating cycles of underperformance.

Other scholars corroborate this. Copur-Gencturk and Tolar (2022) argue that self-assessments have value for building subject-specific confidence, while Mahlambi et al. (2023) support post-training follow-up to refine teachers' feedback techniques. Jeschke et al. (2021), however, do not express optimism regarding gradual improvements, critiquing superficial tracking that ignores deeper barriers like resource shortages. This aligns with Participant 8's call for more implementation aid.

Theoretically, tracking needs and outcomes connects to Wenger's CoPs through follow-up collaborations that extend learning beyond workshops (Smith et al., 2017), and to PCK by using assessments to bridge gaps in pedagogical strategies for complex topics (Driel & Berry, 2017). Implications for skills planning involve embedding mandatory follow-up protocols in national policies, allocating budgets for on-site mentoring to ensure skills transfer, and reducing disparities in teacher efficacy. It can be argued that the current approach to tracking is promising but inconsistent. Based on these findings, it is recommended that standardized digital platforms be used for real-time feedback, mentorship programs be piloted, and partnerships be established with NGOs for scalable support to enhance sustained professional growth.

6.1.3 Provincial curricular priorities

This study found that provincial areas of focus on challenging topics like trigonometry, Euclidean geometry, functions, algebra, and graphs, aligned with annual teaching plans. This addresses educational issues by prioritizing content that bridges primary (General Education and Training (GET)) and secondary (Further Education and Training (FET)) levels, tackling historical curriculum shifts that have resulted in teachers lacking training on topics that were optional in the past. It underscores the need for level-specific CPTD to mitigate student disengagement when taught abstract mathematics.

This aligns with the findings of other scholars: Luneta (2022) advocates for targeting geometry and trigonometry for curriculum coherence, while Whitney-Smith et al. (2022) support alignment with annual plans for technology integration. However, Muyco (2025) disagrees on the adequacy of term-based coverage, arguing it overlooks interdisciplinary needs like data handling, potentially leading to uneven learner preparation (Mwila et al., 2022).

Theoretically, Wenger's concept of joint enterprise in CoPs is evident where provinces collaboratively address shared curriculum challenges (Farnsworth et al., 2016), and Shulman's PCK by focusing on subject-specific misconceptions in

topics like geometry (Star, 2023). For skills planning, this suggests curriculum mapping tools to identify cross-provincial priorities, informing targeted funding for high-need areas and reducing FET dropout risks. We argue that while priorities are well-intentioned, their uniformity risks ignoring contextual variations. As such, we recommend adaptive curricula incorporating inquiry-based methods and annual needs audits, with inter-provincial forums to share best practices (Vale & Graven, 2023).

6.2 Role Players and Providers of CPTD for Mathematics Teachers

6.2.1 Provincial education departments

Participants portrayed provinces as central coordinators, varying in structure and frequency. This indicates centralised delivery, raising issues of resource inequities and manpower strains that fragment the effectiveness of CPTD. This also highlights the tension between policy intent and implementation, where funding limits hinder consistent support. Some scholars, such as Ventista and Brown (2023), support provincial roles in policy execution, while Ghunio et al. (2023) supports partnerships with specialized institutions like CTLI for targeted training.

Elias and Iramba (2022) disagree on the efficiency of delegating CPTD, noting it can lead to inconsistencies. Seen through the lens of the theoretical framework, provinces foster CoPs through workshops and advisor-led sessions (Smith, 2006), enhancing PCK through localized pedagogical focus (Depaepe et al., 2013). This means that skills planning is implicated to include standardizing provincial budgets and manpower, with national oversight to equalize access. Based on these findings, we recommend that CPTD be centralised through a national framework that coordinates training across all provinces—including mandatory cross-district collaborations, to alleviate strains.

6.2.2 National bodies, service providers, and selection criteria

Participants reported that national entities such as DBE, DHET, and SACE collaborated with provinces and external providers (such as universities and NGOs), with varying selection processes. This collaborative network addresses fragmentation but reveals inconsistencies in criteria, potentially compromising quality. Educationally, it emphasizes leveraging external expertise for specialized needs, aligning with global goals like SDG 4.

Abiddin et al. (2022) support the appointment of NGOs to introduce innovation, while Lyon (2022) endorses unions' advocacy. Sowndappan (2023) does not support informal criteria for the appointment of providers, advocating for rigorous tender processes (like those used by Northwest) to ensure alignment with CAPS. Theoretically, this aligns with Wenger's mutual engagement across stakeholders (Smith et al., 2017) and PCK through university-led subject training (Driel & Berry, 2017).

For skills planning, the issue of varying selection processes calls for a centralized provider database with standardized criteria to optimize resource use. As such, we argue that while collaboration has benefits, lax criteria introduce the risk of inefficiency. We recommend SACE-mandated accreditation guidelines and annual evaluations to foster sustainable partnerships.

The findings reveal a CPTD system with potential but hindered by inconsistencies. Integrating CoPs and PCK more robustly could enhance needs identification and provision. For skills planning, implications point to equitable resource distribution and policy reforms. We recommend that the DBE develop a national CPTD strategy emphasizing collaboration, extended support, and data-driven priorities to elevate mathematics teaching and student outcomes in South Africa.

7. Conclusion

This study examined how the professional development needs of mathematics teachers in South Africa are identified and who the key providers and role players are in the CPTD system. The findings revealed that teachers' training needs are determined chiefly through learner performance analysis, teacher feedback mechanisms such as pre- and post-tests, and alignment with curriculum priorities like trigonometry, Euclidean geometry, functions, and algebra.

CPTD provision is coordinated by provincial education departments and supported by national bodies such as the Department of Basic Education and the South African Council for Educators, sometimes collaborating with providers such as universities, NGOs, and professional associations. The analysis highlights important systemic issues: a largely reactive approach to needs identification, uneven resource allocation across provinces, and fragmented coordination among stakeholders. These gaps constrain the sustained impact of CPTD on mathematics teaching and learner outcomes.

8. Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

9. Acknowledgments

The authors wish to acknowledge the use of Grammarly in the writing of this paper. This tool was used to help improve the language and grammar in the paper. The paper remains an accurate representation of the authors' work and intellectual contributions.

10. Funding

The study was funded by the Education, Training and Development Practices Sector Education and Training Authority (ETDP/SETA) under the Mathematics Research chair at the University of the Free State.

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Appendix 1

SEMI-STRUCTURED INTERVIEW SCHEDULE ON THE CONTINUING PROFESSIONAL TEACHER DEVELOPMENT NEEDS OF MATHEMATICS TEACHERS: PROVINCIAL DEPARTMENTS OF EDUCATION

Interviewer	Interviewee	Department or Service Provider	Date of Interview	Time of Interview

INTERVIEW QUESTIONS:

1. Who (which Directorate/Unit) is responsible for the provision of Continuing Professional Teacher Development (CPTD) for mathematics teachers in the Department/Provincial Department?
2. How often are the CPTD Activities (Training, Workshops, etc.) held in a year?
3. Are such activities held at a central venue, and are teachers invited to such activities? If the activities are not held at a central venue, how are the venues for such CPTD activities decided?
4. Which period during the year has been found to be the most suitable for the CPTD activities?
5. Which Phase (Foundation, Intermediate, Senior, FET) has received the most CPTD activities and why?
6. Which mathematics Topics receive the most CPTD Activities?
7. Has the Department (Provincial Departments) monitored the performance of learners following the CPTD? If yes, how has the performance been affected?
8. Does the Department (Provincial Department) partner with Service Provides for the provision of CPTD? If yes, which Service Providers have been used by the Provincial Departments of Education? What are the criteria for the selection of the preferred service providers?