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The Mantle of Teachers' Mathematics Pedagogical Content Knowledge in Teaching and Learning of Grade 12 Mathematics

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ABSTRACT

This exploratory qualitative case study inquired into teachers' Mathematics Pedagogical Content Knowledge and the teaching and learning of Grade 12 Mathematics at two selected secondary schools. Four Mathematics teachers shared their enactment of the teaching and learning of Grade 12 Mathematics when semi-structured interview questions were posed. Further, the teachers' pedagogical content knowledge impacts positively on the learning of Gr 12 learners in Mathematics in the context of a child-centred paradigm of teaching and learning. In addition, the research findings suggest that Mathematics teachers should be subject specialists, generate instructional content that will promote higher-order cognition in learners, can facilitate independent and group work to encourage learners' achievement levels striving towards high Grade 12 achievement still-general exit. Further, Mathematics teachers are expected to use a range of methodological practices relevant to the diverse learning capabilities and needs of all learners in the classroom, therefore enabling students to master content through learner-centred activities. Teachers have to facilitate learning by making abstract content concrete and interactive and get learners actively involved in collaborative group activities for Grade 12 Mathematics learners a success. The study also suggested that Grade 12 Mathematics teachers require professional development to learn learner-centred strategies in the teaching and learning of Mathematics.

KEYWORDS

Pedagogical content knowledge; learner-centred learning; instructional strategy; scaffolding knowledge.

INTRODUCTION

Teaching and learning Grade 12 Mathematics depends on the teacher's pedagogical content knowledge since it affects their choice of instructional strategies (Tondeur et al., 2023). It is not significant to mention that this relationship emphasises the essentiality of developing adaptive learning methods that respond to different requirements for learning, especially in Mathematics Education (Makarova & Herzog, 2023). Mathematics teachers are expected to plan their teaching materials, daily lessons, and teaching learning Mathematics (Mohamed et al., 2023). On top of that, it sheds light on the role of pedagogical innovation in catalysing students' higher-order thinking, critical learning, and problem-solving abilities to promote effective Numeracy teaching and learning (Koh & Chapman, 2019).

To effectively teach and learn Grade 12 Mathematics, teachers need to be competent in content and learner-centred teaching strategies or Mathematics Pedagogical Content Knowledge (MPCK) (Lee et al., 2018). Teachers with higher MPCK tend to use learner-centred teaching strategies, which can successfully facilitate learners' learning of new knowledge (Makofane & Maile, 2019). The constructive learning of Grade 12 Mathematics depends on the teachers' MPCK, which affects learners' mastering of Grade 12 Mathematics (Baumert et al., 2018).

The MPCK of teachers can influence the quality of Mathematics teaching and learning and its outcomes (Koh & Chapman, 2019) because teachers disseminate content knowledge to learners and are responsible for effective teaching and learning (Taufik et al., 2020). Mathematics teachers with a strong grip on MPCK also favour a productive learning environment for their senior secondary Mathematics learners (Ankomah, 2021). Why? Mathematics teacher's understanding of the different types of learning needs that Grade 12 learners possess, can be accommodated, to successfully acquire the new content through the teaching and learning process (Shulman, 1986).

Ball et al. (2008) introduced the concept of mathematical knowledge for teaching (MKfT), which refers to the mathematical knowledge or tasks used in the teaching and learning of Mathematics. These tasks include planning for lessons, evaluating learners' assessments, giving homework, and having discussions with learners with different views on the mathematics curriculum. For effective teaching and learning, Grade 12 teachers must employ communicative pedagogical practices or MPCK to teach content (Ankomah, 2021).

In most cases, teaching and learning of Grade 12 Mathematics are ineffective because teachers lack teaching methodology and content and use teacher-centred learning activities; consequently, learners become passive, leading to underperformance in the subject (Bature, 2020). As suggested by Magabvu (2020), learners' poor performance is due to teachers' lack of MPCK. This point is taken further by Makofane and Maile (2019), who state that the impact of MPCK in teaching and learning Grade 12 Mathematics may lead learners to critically assimilate the content in small groups.

South Africa's (Grade 12) Mathematics learners' performance is poor (Oosthuizen, 2021). For instance, learners cannot analyse and evaluate questions at the National Senior Certificate (NSC) level because they lack proficiency in the content (Awuah & Ogbonnaya, 2020). Grade 12 Mathematics learners' performance depends on how effectively teachers employ teaching and learning strategies in the classroom. (Lee et al., 2018). These different learning strategies should be found in the lesson presentation and used to facilitate learning and teaching (Shulman, 1986). More importantly, teachers' MPCK will assist in implementing appropriate teaching and learning strategies tailored to meet the academic needs of a diverse group of Grade 12 learners and improve mathematical proficiency at the NSC level. Based on the above, the study examines the mantle of teachers' MPCK in the teaching and learning of Grade 12 Mathematics.

Statement of the problem

One of the problems behind the poor performance of Grade 12 learners in Mathematics for the NSC 2019, 2020, and 2021 is that most of them find it challenging to analyse and evaluate mathematical questions (DBE, 2021). This may be due to Grade 12 learners learning Mathematics under the supervision of teachers who lack teaching methodology and content (MPCK) (Lee et al., 2018) and the use of teacher-centred learning activities; consequently, learners become passive, leading to underperformance at the NSC level (Bature, 2020). As suggested by Magabvu (2020), learners' poor performance is due to teachers' lack of MPCK.

Improving learning outcomes in Grade 12 Mathematics depends on the teachers' ability to transfer the content to learners to ensure effective teaching and learning (Taufik et al., 2020; Pule, 2023) and blend with the teachers' MPCK (Neumann et al., 2021). Koh & Chapman (2019) and Hejnova et al. (2018) postulate that teachers with appropriate MPCK can ensure effective learning takes place when they know their learners, adapt instruction to their needs, anticipate misconceptions in their existing knowledge, know curriculum content and the strategies for teaching and learning it and integrate their instruction with that in other subject areas. Against the backdrop, we investigate the mantle of teachers' Mathematics pedagogical content knowledge in the teaching and learning of Grade 12 Mathematics in two selected secondary schools.

Objectives of the Study

1. To investigate the mutual relationship between the teachers' mastery of Grade 12 Mathematics content and their teaching and learning strategies.
2. To examine the effect of teachers' different teaching styles on the academic performance of Grade 12 Mathematics learners.
3. To discover the importance of teachers' understanding of Grade 12 learners' preconceptions, misconceptions, and learning difficulties in facilitating effective teaching and learning outcomes in Mathematics.

Research questions

To address the problem statement, four fundamental questions guide the discussion in the article:

1. What is the mutual relationship between the teachers' mastery of Grade 12 Mathematics content and their teaching and learning strategies?
2. What is the effect of teachers' different teaching styles on the academic performance of Grade 12 Mathematics learners?
3. How do you think the teachers' understanding of Grade 12 learners' preconceptions, misconceptions, and learning difficulties in facilitating effective teaching and learning outcomes in Mathematics?

LITERATURE REVIEW

Teachers need to facilitate Mathematics lessons effectively. To do this, they need a solid base of MPCK to collectively plan and mediate lessons to various learners to adequately learn the new content (Ma'rufi et al., 2018). This is a challenge because most Mathematics teachers need to transform from their traditional role of a knowledge disseminator to a facilitator for effective learning and teaching to take place (Rahman et al., 2021).

Some of the effective teaching and learning strategies highlighted by Taufik et al. (2020) include practical lessons to cater to learners of varying educational needs, learners actively involved in teaching and learning-centred activities, and Mathematical tasks discussing a range of crucial mathematical content. Therefore, learner-centred learning of Mathematics implies a change in the role of the teacher. Mathematics teaching and learning entails the teacher creating learning opportunities for mathematics learners to develop their achievements, mathematical connection ability, and self-esteem in learning mathematics (Sari, 2018).

For effective Mathematics teaching and learning, international scholars have shown that MPCK or the teachers' knowledge of teaching the subject matter is crucial for Grade 12 Mathematics outcomes. (Bature, 2020). Shulman (1986) MPCK refers to Mathematics teachers' understanding of learners' age-related difficulties in grasping and overcoming content. Similarly, Lee et al. (2018) understand that MPCK is the knowledge of teaching and learning learners with grade-appropriate misconceptions. Therefore, MPCK is defined as the knowledge of teaching and learning Mathematics, which includes the curriculum's scope, educational objectives, and adequate teaching resources (Moh'd et al., 2021).

Shulman (1986) MPCK is a concept that merges the teachers' Mathematics content knowledge and pedagogy (how to teach) specific to Mathematics education. MPCK is a distinguished body of knowledge a Grade 12 Mathematics teacher must possess, empowering the teacher to create learning opportunities by using various skills and knowledge to facilitate Mathematics learning amongst groups of learners to make sense of it (Shulman 1986). In other words, MPCK enables mathematics teachers to use a variety of teaching and learning strategies to mediate the learning content of Grade 12 mathematics to learners (Miller & Krajcik, 2019).

One teaching strategy Sari (2018) put forward is a scaffolding of the learning content, which depends on the quality of instruction within exceptional encounters with the

mathematics teacher. Taufik, et al. (2020) stated that effective Mathematics learning can occur in a social constructivist classroom when the scaffolding of new knowledge is based on existing knowledge. In other words, learners' grounding knowledge (intermediate and senior phase) in Mathematics forms the foundation for Grade 12 learners to learn Mathematics (Hejnová et al., 2018).

Scaffolding in Mathematics education is crucial in enhancing learners' learning outcomes, particularly when teachers connect new content with learners' prior knowledge (Van de Pol et al., 2022). Addressing misconceptions through adaptive teaching has also proven effective in facilitating meaningful learning experiences (Chan & Lee, 2023). Scaffolding of content will enable learners to gain small achievements and ultimately achieve cognitive growth just beyond their grasp (Bell, 2010; Pasigon, 2024). In scaffolding mathematics learning, teachers should produce insight from the excellent feedback from learners who engage in group activities to recognise and continue with the learning opportunities designed for the classroom (Koh & Chapman, 2019).

The process of the scaffolding of knowledge emphasises learning is centred around the learners, allowing them to construct a large and flexible knowledge bank to effectively enhance learners problem-solving skills, active collaborators of lifelong learning, and intrinsically inspired to learn (Sari, 2018). Mathematics teachers should guide learners by posing probing questions to keep them focused on the learning objectives (Aidoo et al., 2016; Pule, 2023). During the dialogue encounters, the teacher guides the successful instruction in mathematical problem-solving, which results in the scaffolding of knowledge accompanied by the scaffolding of dialogue (Klang et al., 2021; Noor, 2022). Therefore, the mathematics teacher guides Grade 12 learners on innovative ways of thinking, new understandings, and arguments for their problems, thereby constructing new knowledge based on their previous knowledge (Mondal, 2023).

The role of the teacher in Mathematics in the scaffolding process is to facilitate learning through learners-focused activities instead of disseminating information to them and posing open-ended questions to trigger their thoughts to supply creative answers to problems (Klang et al., 2021). Furthermore, mathematics teachers provide methodical guidance in conceptual, well-thought-out reasoning for mathematics problem sums, which will culminate in improved academic performance among the groups of learners (Muntari & Ahmed, 2020).

Learning Mathematics under the guidance of the facilitator (Mathematics teacher) while learners are doing group work creates a space whereby learners feel comfortable exploring new thoughts and raising questions to each other or their teacher about the new content (Muntari & Ahmed, 2020). More importantly, group work develops learners' communication skills and group dynamics (Cengiz & Kacar, 2024, Panfilova et al., 2024) because group work motivates learners to be actively involved and accountable for their actions and can lead to gains in Grade 12 Mathematics, while the subject teacher monitors the learning activities and reciprocating information where necessary (Koh & Chapman, 2019). Furthermore, this allows learners to

practice the newly acquired content under the caretakers of more knowledgeable Mathematics teachers, increasing their thinking ability (Koh & Chapman, 2019; Mondal, 2023).

Nurlaily et al. (2019) mention the advantage of teachers having a well-endowed MPCK exposes learners to problems that resemble authentic real life; learners are self-motivated to learn actively, exposes them to various learning situations, and allows learners to collaboratively find solutions and improve learners' achievements in Grade 12 Mathematics, under the safe eye of the teacher. Furthermore, Mathematics learners can develop new information and expertise through their encounters in the classroom while solving life-like problems in the presence of a knowledgeable person (Koh & Chapman, 2019; Yulian & Wahyudin, 2018).

Teachers' MPCK directs them to plan lessons to effectively instruct Grade 12 learners on the content that appeals to their cognitive demands and age-appropriate understanding. In other words, the simulated problems posed to learners in the classroom, representing authentic life challenges, must be relevant to their context, learners-focused, collaborate on new knowledge, and be self-directed in their learning (Koh & Chapman, 2019; Pule, 2023).

The Mathematics teachers are the designers and implementors of the learning scenarios, focused on learner-centred conditions to transform low Mathematics levels into higher performance gains (Koh & Chapman, 2019; Noor, 2022). Teachers are facilitators, guiding the resources to learners to develop their problem-solving skills. Mathematics teachers must create learning challenges that appeal to learners' cognitive levels and enable them to identify new solutions using newly acquired skills and knowledge through creative dialogic spaces (Klang et al., 2021; Pasigon, 2024). If this does not happen, learners become passive in Mathematics learning, leading to poor performance levels in Grade 12 (Aidoo et al., 2016).

The critical role of teachers with a high command of MPCK is to plan and assist learners in managing their time in the learning process, which cannot be ignored. Furthermore, teachers must induce a Mathematics classroom whereby learners receive systematic instruction in conceptual, strategic, and reflective reasoning on the content (Awuah & Ogbonnaya, 2020; Brijlall & Ivasen, 2022). An arbitrary learning environment encourages learners to take responsibility for their learning and suggests positive improvements in Grade 12 Mathematics assessments (Lee et al., 2018).

THEORETICAL FRAMEWORK

The study uses Shulman's (1986) theoretical perspective, specialised mathematical knowledge (SMK), to investigate the mantle of teachers' MPCK in the teaching and learning of Grade 12 Mathematics. Shulman describes SMK using two categories of knowledge: Mathematics Pedagogical Content Knowledge (MPCK) and Specialised Mathematics Knowledge (SMK). MPCK as a construct entails merging content and pedagogy unique to Mathematics teachers' education.

Teachers depend on their SMK to teach Mathematics and are trained explicitly (Bature, 2020). Ankomah (2021) concurs with Shulman (1986) that SMK is a form of knowledge that

refers to the specialised knowledge needed for effective teaching and learning of Grade 12 Mathematics. Therefore, the Mathematics teacher's mastery of the learning content is essential for effectively communicating the learning content to Mathematics learners. Shulman (1986) referred to Mathematical content knowledge as a specialised or technical form of content knowledge that entails teaching learners (Ball et al., 2008). Therefore, teachers' communication of the content demands high-quality instruction for effective teaching and learning in Grade 12 Mathematics (Ball et al., 2008). Other scholars (Ma'rufi et al., 2018) aver that a good command of content knowledge is critical to Mathematics instruction and quality outputs in learning.

Knowing the content well does not inherently mean that mathematics teachers can generate an effective teaching and learning environment. For this to happen, Grade 12 Mathematics teachers must be endowed with MPCK (Bature, 2020). MPCK equips mathematics teachers to understand what conditions lead to learning a specific topic as easy or challenging, understand grade 12 learners' preconceptions, misconceptions, and learning difficulties, and how to facilitate effective teaching and learning. More importantly, teachers would know how to frame the Mathematics content knowledge and their understanding of the learning difficulties faced by Grade 12 learners while experiencing a specific topic.

According to Shulman (1986), Mathematics teachers depend on their MPCK when they travel beyond comprehending the subject matter, can restructure the content, and reproduce it to meet the various learning needs of Grade 12 learners. In other words, Mathematics teachers have the skills and knowledge to create lessons with suitable learning methodologies for effective teaching and learning and conceptual comprehension (Brijlall & Ivasen, 2022).

Ankomah (2021) mentions that teachers create lessons using appropriate learning methodologies that depend on their MPCK. The scholars have categorised MPCK into four important sub-categories firstly, the awareness and thoughts about the reasons for teaching and learning Mathematics at various grades; secondly, the understanding of Mathematics learners' comprehension and misunderstandings of a specific topic; thirdly, the knowledge of curriculum materials available for teaching and learning Mathematics, which include a thorough comprehension of the content and lastly, the skills and knowledge of instructional teaching and learning strategies and renditions for presenting a Mathematics concept to Grade 12 learners.

Therefore, using Shulman's theoretical framework (1986) is relevant because the knowledge and beliefs about the role and function of teaching and learning Mathematics serve as an overarching conception of teachers' teaching. Furthermore, the teachers' knowledge of their learners' needs and what content is suitable for them will help determine the most suitable strategies used to deliver the content. To plan an effective teaching and learning event in the Grade 12 Mathematics classroom, teachers will consider their learners' characteristics such as previous knowledge (scaffolding of knowledge) and their ability, leading to a meaningful and effective learning and teaching event.

METHODOLOGY

This is a qualitative study, utilising a case study approach to examine the mantle of teachers MPCK in the teaching and learning of Grade 12 Mathematics. Purposive sampling was used to select two secondary schools situated in Newcastle, in the Amajuba district in the province of KwaZulu-Natal. These schools' teachers best understood the problem and the research question. The researcher used year-end district reports to identify the two secondary schools. Using the criteria, one school consistently performs above the 80% average, and the other consistently underperforms below the 65% average in the National Senior Certificate for 2020, 2021, and 2022. Based on this, the two Grade 12 Mathematics teachers from each respective school were chosen for the interview. The researcher posed semi-structured interview questions to the participants to gather data on the phenomenon under review. Thematic data analysis was used to interpret the data.

Research Paradigm

This study used an interpretivism paradigm because qualitative studies depend primarily on the multiplexed realities of the respondents (Creswell, 2016). The interpretative approach is focused on the process of constructing new knowledge from the understanding of the actions of the Grade 12 Mathematics teachers in their environments (Creswell & Creswell, 2018). Therefore, conducting semi-structured interviews with the teachers enabled the researchers to understand how the respondents made sense of the phenomena under review in the Grade 12 classroom (Creswell & Creswell, 2018).

This meant by using interpretivism, a significant amount of importance was placed on the information obtained from the research participants via interviews. In other words, the researchers gained rich and detailed data on teachers' MPCK in the teaching and learning of Grade 12 Mathematics. Furthermore, the interpretivism paradigm enabled the investigators to capture their experiences' intricacies and understand the phenomenon under review.

Overall, the paradigm of interpretivism allowed the investigators to understand the subjective side of the Grade 12 teachers teaching Mathematics and the impact of their MCK on their classroom environment. With an emphasis on interpretation, context, and meaning, this study would contribute to a higher comprehension of the complexities of the teaching and learning of Grade 12 Mathematics.

Research Design

The research design was a qualitative case study that was used to investigate the mantle of teachers' MPCK in the teaching and learning of Grade 12 Mathematics because it focuses on the natural setting, that is, the classroom where the participants interact (see Creswell 2016:53). A qualitative study is used, which was interpretively allowed for the investigation of the phenomena by interviewing the subject teachers. In this way, the researchers would be able to conduct an in-depth empirical review by earning a rich and detailed understanding of the mantle of teachers' MPCK in teaching and learning Grade 12 Mathematics. For this study, the researchers focused on a single case to investigate the phenomenon under review that might

not be observable in other scenarios. Teachers' ability to recognise and address student misconceptions through adaptive strategies is a critical component of effective teaching (Chan & Lee, 2023). This approach, combined with collaborative learning strategies such as group work, has been shown to foster a more engaging and productive learning environment (Hmelo-Silver et al., 2022).

Population and Sample

A purposive sampling technique was utilised to select two secondary schools in Newcastle, in the Amajuba district in the province of KwaZulu-Natal. The criteria used to identify the schools were one school consistently performing highly (above 80% average) and the other consistently underperforming (below 65% average) in the National Senior Certificate (NSC) for 2019, 2020, and 2021 (DBE, 2021). Year-end district reports were used to identify the two secondary schools.

It was envisaged these schools would assemble rich-endowed data on the elements under investigation. Purposive sampling was used to select two Mathematics teachers from each secondary school teaching Grade 12 Mathematics. Aguboshim (2021) opined that since the objective of qualitative research is for an in-depth exploration study rather than inferable or relational, the concern of the sample size has little impact on the investigation's validity. Therefore, the researchers perceived that the four teachers selected were rich in comprehension, skills, encounters, and attitudes because of their teaching experience in Grade 12 Mathematics (Creswell & Creswell, 2018).

Data Analysis

Semi-structured interviews with Grade 12 Mathematics teachers were conducted in the study and the data were analysed thematically. Thematic analysis was used to identify and organize the main themes regarding teachers' MPCK practice. Such themes included scaffolding, differentiation, and the effect MPCK had on students' engagement and performance. The transcripts of interviews were coded identifying themes through systematic categorization. The methodological rigour earned through three rounds of evaluations ensured that the analysis accurately reflected both overt and subtle manifestations of ways in which teachers drew on their MPCK to meet learners' varying needs.

It also included what the researchers referred to as reflective triangulation (comparing across findings and responses) to validate consistency and depth. The connection of the identified themes with Shulman's MPCK model theoretically framed the study, enhancing data-theory link and analytical rigour. This consolidated approach enabled the study to pinpoint support mechanisms that enhance Mathematics learning outcomes.

Validity and Reliability

To confirm the validity of this study, the following strategies were used:

Triangulation: Different sources of data (teacher interviews, and school performance reports) were cross verified to check the validity of the findings. This provided reliability and validity to the findings (Creswell & Creswell, 2018).

Member Validation: Read through the transcripts and interpretations to allow participants to validate their comments (Brijlall & Ivasen, 2022), and perspectives ensuring trustworthiness.
The detailed documentation of data collection and analysis processes ensures an audit trail, facilitating transparency and replicability, which are in line with Rahman et al. (2021).
Researcher Reflexivity: The researchers kept a reflexive journal to identify possible biases and reflect on how their views may shape data interpretation (Creswell, 2016).
All these steps assured the trustworthiness and credibility of the study (i.e., that new design findings arose meaningfully from data representing their substance). Such concepts included how triangulation and member checking helped to mitigate bias, and reflexivity ensured researchers were critically aware of their positionality in interpreting the data.

DISCUSSION OF RESULTS

In response to research question one: **"What is the mutual relationship between the teachers' mastery of Grade 12 Mathematics content and their teaching and learning strategies?"** The participants commented as follows:

> *My mastery of content allows me to re-explain abstract content differently to slower learners, using real-life situations, and this inspires confidence in my learners' learning*. (Teacher 1)
>
> *Knowing the content helps me use various strategies to teach. A teacher with limited knowledge cannot facilitate group work to meet learners' various learning demands.* (Teacher 2)

Both teachers asserted that their mastery of content influenced their choice of teaching strategies for teaching and learning Grade 12 Mathematics. They further stated that mastery of the content inspired confidence in the learners to learn Mathematics. The interviewees' responses suggested that knowing the Mathematics content well enabled them to re-explain any Mathematics questions and provide appropriate learning support to meet learners' various learning needs. The interviewees contended that they were masters of Grade 12 content; they could facilitate group work, and content endowed permitted learners' inspiration to learn. These results are consistent with Ma'rufi et al. (2018), who state that mathematics teachers' strong command of MPCK influences their learners' content acquisition. The scholars added that since teachers use methodologies to provide learning in direct proportion to learners' learning demands, this translates into improved performance outputs.
Teacher 4 gave the following response:

> *If you know your content, you'll be able to teach differently, with different methods or steps, to learners with varying learning needs successfully.*

Teacher 4 argued that with a strong command of the Mathematics content, he could use different teaching and learning strategies for learners with varying learning demands to communicate the content successfully.

The data from the interviewees revealed that Mathematics teachers with in-depth knowledge of the content would know how to expose the content to learners with different learning needs and succeed. Similarly, Shulman (1986) classified MPCK as the teachers' understanding of mathematical concepts and how to comprehend them so that learners assimilate the content according to their learning needs.

The succeeding question was posed to the participants as a follow-up to research question one, **"Discuss an effective teaching strategy you used in teaching Grade 12 Mathematics after discovering that learners did not grasp the content initially teaching the concept?"** The participants commented as follows:

> *After teaching a concept, if learners still have a problem, I then shift focus onto them…I pose direct or sometimes leading questions, moving from the known to the unknown, building new content on their existing knowledge…* (Teacher 1)
>
> *With learners having barriers to learning, I motivate the lower, middle, and higher-pace learners. I incorporate all assessments so that everyone is motivated; otherwise, people will get bored.* (Teacher 2)

Both teachers declared that after discovering that Grade 12 Mathematics learners did not initially grasp the content through a teacher-centered approach, the participants changed to learner-centered learning. Their responses suggested that leading the mathematics learning was more effective because the learners actively experienced the content by constructing the new content based on their foundational knowledge under the watchful eye of the teachers.

This finding supports previous research by Sari (2018) that scaffolding of learning content depends on the teachers' high calibre of guidance within the realms of the mathematics classroom, which would translate into achievement gains. From the interviews with the teachers, it seems that their teaching styles positively impacted their learners' Mathematics performances in Grade 12.

The interviewees contend that employing a differentiated approach to cater to a heterogeneous group of active learners using different assessment levels encouraged them to learn. Additionally, Mathematics teachers depended on their mastery of knowledge (MPCK) to reorganise their teaching and reproduce it to meet the various learning needs of Grade 12 learners (Shulman, 1986). Similarly, Nurlaily et al. (2019) opine that the inclusivity of learners with various learning needs is satisfied, and learners are instinct-motivated to participate in groups to make sense of the content actively.

From the interviews with the teachers, the data revealed that Mathematics learning is more effective when the teachers are strong in their MPCK and can manipulate the content to meet the differentiated learning needs of learners, for example, through learner-centred learning. Therefore, teachers need to mediate the learning content by scaffolding and understanding the learning difficulties faced by Grade 12 learners while experiencing a specific topic (Shulman, 1986) and teach the new content in proportion to learners' varying educational needs (Taufik et al., 2020; Pule, 2023). For this to happen, Mathematics teachers should be

masters of the content to successfully implement various teaching and learning methodologies like learner-centred learning and scaffolding of the new content.

The data further disclosed that Mathematics teachers' MPCK assisted them in designing and implementing flexible mathematical lessons and learner-centred learning using various assessment forms to help learners acquire the content (Awuah & Ogbonnaya, 2020; Pule, 2023).

In response to research question two, **"What is the effect of different teaching styles teachers employ on the academic performance of Grade 12 Mathematics learners?** The participants commented as follows:

> *I am knowledgeable in many different teaching methodologies… I use problem-solving and group work methodologies to cater to learners with various learning abilities. They borrow a textbook, study a chapter, and independently present to the class with excellence.* (Teacher 2)
>
> *As a teaching strategy, group work does not work for me because I don't know how to do it. Besides, learners in a group of six… one person knows the others write down the answers; therefore, I used teacher-centered teaching strategies.* (Teacher 3)

Teacher 2 attested that facilitating lessons in smaller groups in the classroom has produced learners with excellent results in Grade 12 Mathematics. The respondent further argued that learner-centred problem-solving techniques had taught learners to be independent and could peer-teach the class with high-quality passes.

Teacher 3 maintained that using group work as a learning strategy is challenging to implement for two reasons; he did not know how to conduct group- learning, and secondly, one learner dominated the learning while others became passive receivers of the content. The respondent contended that he used the lecture method to teach Mathematics in the classroom.

Teacher 2 asserted that teachers knowledgeable in teaching strategies can facilitate effective Mathematics lessons and positively change learners' performances. Likewise, Makofane and Maile (2019) stated that Mathematics teachers must be flexible in their lesson presentations. This means that Grade 12 Mathematics teachers must be capable of adapting the content to the cognitive levels of heterogeneous classes in a socially collaborative atmosphere to achieve positive learners' achievements. Similarly, Mathematics teachers employ their MPCK when they need to adapt their teaching and learning of Mathematics so that different learners can now comprehend the new concepts (Shulman, 1986).

Responding to research question three, **"How do you think the teachers understand Grade 12 learners' preconceptions, misconceptions, and learning difficulties in facilitating effective teaching and learning outcomes in Mathematics?"** The participants commented as follows:

> *Knowing their misconceptions, I am expecting them. I already have the solutions. Those misconceptions keep popping up… because of your past teaching experience.* (Teacher 2)

Teacher 2 asserted that pre-knowing the challenges learners may experience in learning the content allowed him to adapt their lesson delivery from the initial presentation to meet the

learning needs of learners. Their response suggested that a teacher who understood learners' challenges of learning a particular concept can effectively pre-plan their lesson delivery, thereby minimising learners' struggles in acquiring the content.

The interviewee contended that mathematics teachers should know the potential struggles that Grade 12 mathematics learners might experience in learning new concepts and should use age-appropriate teaching strategies or adaptive methodologies to ensure effective learning. This study confirms Ma'rufi et al.'s (2018) study that mathematics teachers skilled in MPCK could foresee learners' challenges in learning new content or apply multiple ways of presenting the content to produce meaningful learning. Similarly, Shulman (1986) also believes that MPCK allows teachers to understand the pre-conditions that could result in learning a specific topic as easy or difficult and then mediating effective teaching and learning situations.

FINDINGS

The key findings of our research are based on the overall aims of the study, that is the Mantle of Teachers' MPCK in the teaching and learning of Grade 12 Mathematics. The first probing question was, "What is the mutual relationship between the teachers' mastery of Grade 12 Mathematics content and their teaching and learning strategies?" Responding to the first research question, the findings advocate that teachers' mastery of the content enables the re-teaching of Grade 12 learners who did not initially grasp the content by using different teaching and learning strategies, like group work, appropriate to their various learning needs. Furthermore, the participants contend that the mastery of content and delivery (MPCK) inspired confidence in learners to learn Mathematics. Similarly, Muntari and Ahmed (2020) stated that learners learning Mathematics under the supervision of a knowledgeable teacher now feel comfortable discovering new ideas and putting forward questions to each other or their teacher about the new content. These results are consistent with those of Ma'rufi et al. (2018), who state that the mathematics teachers' strong command of MPCK motivated learners to learn and influenced their content acquisition. The view is, "I would say the teacher must be well endowed with subject matter so that you can present lessons catering to the different learning needs of your learners and intrinsically motivate them…" This finding is supported by Shulman (1986), who states that content mastery refers to the teacher's knowledge of the curriculum and their learners' various learning abilities. Therefore, teachers with a firm grip on the content can employ teaching and learning strategies to concretise abstract concepts that complement the learning styles of Grade 12 Mathematics learners. To achieve this, teachers must construct and present lessons to effectively capture Grade 12 learners' cognitive interests. According to Pule (2023), the teachers' MPCK enables the conversion of theoretical concepts into authentic life situations for learners to teach and learn effectively. (Koh & Chapman, 2019; Pule, 2023).

The findings also show that effective teaching and learning occurs through the scaffolding of content facilitated by the Mathematics teachers (Sarker et al., 2019). The role of the mathematics mediator is to scaffold the new content proportionally to learners' varying educational needs in Grade 12. To achieve this, the teacher must ascertain the required learning

opportunities to help learners move from previous knowledge to new knowledge (Amineh & Asl, 2015; Pule, 2023). The view, "When I teach, I like to re-teach the basics (Grade 10 work) and then build up (new knowledge), then it assists them…" This view coincides with the studies by Sarker et al. (2019) and Vintage (2018) that Mathematics teachers, in their newfound role, need to mediate the new mathematical knowledge through scaffolding. Therefore, learners are now more active in the Mathematics lessons, feel more confident, and tend to pose clarity-seeking questions that lead them to collectively build the new content (Ma'rufi et al., 2018; Pule, 2023).

Mathematics teachers need to cater to the different learners in the classroom therefore, the findings recommend that lessons presented in the Mathematics classroom must be flexible. Flexible lessons cater to Mathematics classroom learners with various learning abilities. The view, such as "So, I don't use the example or teaching method that challenged the learners. You will use different methods in one class …" supports this finding. Furthermore, Ankomah (2021) opines that teachers with strong MPCK can design and implement lessons catering to learners with various learning challenges to grasp the content.

The second probing question was, "What is the effect of different teaching styles teachers employ on the academic performance of Grade 12 Mathematics learners?" In response to this research question, the findings showed that teachers' knowledge use of various teaching strategies can effectively facilitate Mathematics lessons and positively change learners' performances.

More importantly, the findings of the study showed that teachers using various teaching methodologies like group work and scaffolding encouraged learners to be active in the learning and teaching process, often working collaboratively to make sense of the content. In other words, the teachers' MPCK assists in designing and implementing flexible mathematical lessons through practical investigative group work. The view, "Grade 12 learners can work in groups, and they will try and answer it together. I just need to monitor and guide their answers." This complements Klang et al. (2021) study that Grade 12 learners can lead group discussions more effectively than most teachers because they learn much better from their peers and achieve positive academic results. The findings further show that Mathematics teachers are no longer the only source of knowledge spewing out the content to learners, but according to Aidoo et al. (2016), should pose probing questions that will enable them to collectively make sense of learning the content and experience improved performance levels. The findings showed that teachers need a strong capacity of MPCK to collectively plan and mediate lessons, moving away from their traditional role of a knowledge disseminator.

The final probing question was, "How do you think the teachers understand Grade 12 learners' preconceptions, misconceptions, and learning difficulties in facilitating effective teaching and learning outcomes in Mathematics?" Responding to this question, the findings advocate knowing learners' preconceptions, misconceptions, and learning difficulties before the commencement of a lesson, which is beneficial for effective teaching and learning of the content. Most participants agreed that this allowed them to facilitate mathematics lessons

catering to each child's learning needs. Furthermore, knowing their learning challenges before the presentation means that the teacher can adapt their lesson plans to obviate the learning problems the teachers are expecting, thus making teaching, and learning outcomes in Mathematics more productive. The view, "... *Pre-knowing those learners finding Mathematics challenging in the Commerce class (lower performing) … My lessons are planned according to their learning needs by going slower. While in the Physics class (higher performing), I can move faster, so it is very different from the two classes*."

This finding aligns with Moh et al.'s (2021) study that MPCK is the resource teachers will use to understand mathematics learners' age-related preconceptions and misconceptions and build lessons using various instructional strategies like group work or scaffolding of content. In other words, the teachers' MPCK (knowing learners' misconceptions) will influence the choice of learning strategies used, especially when they adopt pedagogical representations of content, use questioning strategies, knowledge of assessment, evaluation of research, and provoke them into self-directed learning (Martin, 2022). The successful dissemination of Mathematics content to Grade 12 learners by teachers depends upon their understanding of learners' preconceptions, misconceptions, and challenges they may have so that constructive teaching and learning takes place.

The findings align with recent research showing that teachers with strong MPCK are better equipped to use varied teaching strategies that cater to different student needs, thereby enhancing academic outcomes (Makarova & Herzog, 2023). Similarly, using group work as a teaching strategy is effective in improving students' understanding and engagement in Mathematics (Hmelo-Silver et al., 2022).

CONCLUSIONS

This study investigated the mantle of teachers MPCK in the teaching and learning of Grade 12 Mathematics in two selected secondary schools in the Amajuba District in Newcastle, KZN. The study's outcome relates explicitly to the aims and objectives of the research undertaken. The study findings show that teachers' mastery of the content enables the use of differentiated approaches in the teaching and learning of Grade 12 Mathematics. These learners who did not initially grasp the content now re-taught the lesson with appropriate teaching and learning strategies catering to their various learning needs. The study's second finding shows that teachers' knowledgeable use of various teaching methodologies, such as group work, encourages learners to participate in the mathematics lesson, often working collaboratively to make sense of the content. Teachers' use of scaffolding, particularly when aligned with learners' existing knowledge, significantly impacts their cognitive growth and learning achievements (Van de Pol et al., 2022). Understanding learners' learning difficulties and preconceptions is crucial in adapting instruction to meet diverse needs, ultimately fostering better learning outcomes (Chan & Lee, 2023). Lastly, the study findings show that Mathematics teachers know their learners' learning challenges before the lesson presentation, allowing the adaptation of the lesson to

their learning needs to obviate the learning problems the teachers anticipate, thus making teaching and learning outcomes in Mathematics more productive.

Recommendations

The study suggests expanding research on teachers' MPCK to other areas within the Amajuba district and increasing observational time during lessons. This would allow for the results to be generalized, providing valuable insights for Grade 12 Mathematics teachers on effective teaching strategies. The study emphasizes the need for ongoing professional development through incentives, workshops, and active Professional Learning Communities (PLCs) to enhance teachers' mastery of content and delivery. It also recommends that teachers adopt flexible teaching methodologies, such as group work and scaffolding, to encourage active learning rather than traditional, teacher-centred approaches. Teachers should understand the learning difficulties faced by learners to effectively plan and present lessons that cater to diverse educational needs. The ultimate goal is to transform teaching practices, making lessons more learner-centered and engaging, which can lead to improved academic outcomes for Grade 12 Mathematics learners.

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