

Beyond the basics: A qualitative exploration of mathematics teaching effectiveness in South African secondary schools

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Abstract

In the world of teaching mathematics, significant disparities persist in teaching effectiveness and the interventions employed by educators. This study investigates the challenges faced by mathematics teachers and explores interventions to enhance learner performance. Through a qualitative research design, seven dedicated mathematics teachers were sampled using a purposive snowball sampling approach. Data were gathered through structured interviews with participants from selected secondary schools in the Madibeng Local Municipality. The study findings underpin the hurdles teachers encounter, including insufficient resources, congested annual teaching plans, demotivated learners, ill-discipline, and subject coercion. These issues are further compounded by the broader educational inequalities in the South African education system, a legacy of its fragmented and unequal education system inherited from the apartheid dispensation. Despite these challenges, government schoolteachers adopted effective strategies such as scaffolding, weekly assessments, the use of past exam papers, and learner-centered approaches. The study concludes that to enhance teaching effectiveness, teachers need robust support and adequate resources. Additionally, government bodies, school heads of departments, and principals must effectively collaborate to provide these necessary support and resources, thereby improving learner outcomes and reducing dropout rates. This study contributes invaluable insights into the complexities of teaching mathematics, highlighting effective practices and interventions to keep learners engaged and prevent them from swaying away to mathematical literacy or leaving school altogether.

Keywords: Mathematics excursions, Educational inequalities, Robust support, Government collaboration

Abstrak

Dalam dunia pengajaran matematika, masih terdapat kesenjangan yang signifikan dalam hal efektivitas pengajaran dan pendekatan yang digunakan oleh para pendidik. Penelitian ini bertujuan untuk mengkaji tantangan yang dihadapi oleh guru matematika dan mengeksplorasi intervensi untuk meningkatkan kinerja siswa. Melalui desain penelitian kualitatif, 7 guru matematika dipilih sebagai sampel dengan menggunakan pendekatan *purposive snowball sampling*. Data dikumpulkan melalui wawancara terstruktur dengan para peserta dari sekolah menengah terpilih di Kotamadya Madibeng. Temuan studi ini mendukung rintangan yang dihadapi guru, termasuk sumber daya yang tidak mencukupi, rencana pengajaran tahunan yang padat, siswa yang tidak termotivasi, disiplin yang buruk,

dan tekanan mata pelajaran. Masalah-masalah ini semakin diperparah oleh ketidaksetaraan pendidikan yang lebih luas dalam sistem pendidikan Afrika Selatan, yang merupakan warisan dari sistem pendidikan yang terpecah-pecah dan tidak setara yang diwarisi dari masa Apartheid. Terlepas dari tantangan-tantangan ini, guru-guru sekolah pemerintah mengadopsi strategi yang efektif seperti *scaffolding*, penilaian mingguan, penggunaan soal ujian sebelumnya, dan pendekatan yang berpusat pada siswa. Penelitian ini menyimpulkan bahwa untuk meningkatkan efektivitas pengajaran, guru membutuhkan dukungan yang kuat dan sumber daya yang memadai. Selain itu, badan-badan pemerintah, kepala sekolah, dan kepala sekolah harus berkolaborasi secara efektif untuk menyediakan dukungan dan sumber daya yang diperlukan, sehingga dapat meningkatkan hasil belajar siswa dan mengurangi angka putus sekolah. Penelitian ini memberikan wawasan yang tak ternilai mengenai kompleksitas pengajaran matematika, menyoroti praktik dan intervensi yang efektif untuk membuat siswa tetap terlibat dan mencegah mereka berpaling dari literasi matematika atau meninggalkan sekolah sama sekali.

Kata kunci: Ekskursi matematika, kesenjangan pendidikan, Dukungan yang kuat, Kolaborasi pemerintah

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INTRODUCTION

In the world of teaching mathematics, the quest for effective teaching strategies and interventions remains a pressing concern. Despite the dedication and resilience of educators, significant disparities in teaching effectiveness and interventions employed continue to challenge the field (Coles & Brown, 2021; Nelson et al., 2022). The South African public school system post-apartheid is still a microcosm of the broader societal inequalities that persist in the country, especially in previously disadvantaged communities. The apartheid legacy has left an ineradicable mark on the education sector, resulting in a bimodal system where a small percentage of schools perform exceptionally well, while the majority continue to struggle with inadequate resources and poor outcomes (Van der Berg & Gustafsson, 2019; Clercq, 2020). From insufficient resources and congested teaching plans to demotivated learners and disciplinary issues, the hurdles are numerous and complex in government schools (Ahmed et al., 2020; Letshwene & Du Plessis, 2021; Aguhayon et al., 2023).

Additionally, these challenges are further compounded by the perpetual educational inequalities rooted in South Africa's apartheid legacy (Van der Berg & Gustafsson, 2019; Clercq, 2020). Despite these delimitations, teachers are not merely surviving, they remain innovative and resilient. That is, adopting strategies such as group discussion (Roshni & Rahim, 2020; Crisianita & Mandasari, 2022), scaffolding content (Rahma et al., 2020; Kruiper et al., 2022), learner centeredness (Komatsu et al., 2021), behaviour management (good game behaviour) which allows learners an equal chance to fulfil their potential in the classroom, that is, they get rewarded for



good behaviour and no reward for ill behaviour (Chen, 2023; Kusumawati et al., 2023; Peltier et al., 2023). Additionally, blended learning (Du et al., 2022; Widjaja & Aslan, 2022; Ayob et al., 2023) and gamification (Putz et al., 2020; Krishnamurthy et al., 2022; Luo, 2022).

Several authors demonstrate that to build a strong foundation in mathematics, it is crucial to introduce mathematical concepts in the early grades (Papadakis et al., 2021; Humphreys & Parker, 2023; Tañola and Lomibao, 2024). This early exposure can enable learners to develop a solid understanding that can be built upon in later years. Engaging experts in the field to address and motivate learners can provide valuable insights that inspire learners to pursue further studies in mathematics (Sriratanaviriyakul & El-Den, 2017; Sriratanaviriyakul & El-Den, 2019; Hosen et al., 2021).

Organizing mathematics excursions, including field trips and making mathematics more practical can help learners see the real-world applications of what they are learning, making the subject more interesting and meaningful (Palia, 2020; Kong, 2021; Uyen et al., 2021; Wijaya et al., 2021; Biber et al., 2022; Rugaiyah, 2022; Viberg et al., 2023). Additionally, it is important to avoid assigning non-specialist teachers to teach mathematics, as specialist teachers are better equipped to deliver the subject matter effectively (Crisan & Rodd, 2017; Van Putten et al., 2022).

Despite numerous studies on teaching mathematics, specifically in secondary schools and interventions aimed at enhancing teaching effectiveness, there remains a significant gap in understanding the specific practices that constitute teaching effectiveness in under-resourced, marginalized and historically disadvantaged secondary schools. While previous research has highlighted general educational disparities and the apartheid legacy on the education system (Van der Berg & Gustafsson, 2019; Clercq, 2020), there is a need for a detailed qualitative insight into the exemplary practices and effective strategies employed by secondary school educators who achieve better results in these challenging contexts. This study aims to address this gap by providing an in-depth analysis of teaching mathematics within the Madibeng Local Municipality, focusing on the lived experiences of mathematics educators who thrive in their roles and uncovering effective strategies and interventions to boost learner performance.

METHODS

Study design and Setting

This study used a qualitative, exploratory and descriptive research approach. Given the lack of information on the challenges faced by mathematics teachers in the Madibeng Local Municipality, there is a need for exploratory qualitative studies. Thus, this exploratory study was conducted to explore the challenges faced by mathematics teachers. Kim, Sefcik and Bradway (2017) used systematic review research to show that qualitative description research offers a detailed textual description of respondents. This paper follows their approach.

This qualitative descriptive survey study was conducted from June 2023 to September 2023 in the North-West Province, Madibeng Local Municipality district. This district, one of five in the region (including Moses Kotane, Moretele, Rustenburg, and Kgetleng River), is nestled between the Magaliesberg and Witwatersrand Mountain ranges. The name "Madibeng," meaning "the place of water," reflects the area's natural beauty and abundant water resources, such as the Hartbeespoort, Rooikoppies, Vaalkop, and Klipvoor Dams, which are significant tourist attractions (Lehotlha, 2015).

The Municipality is divided into 31 wards, with 10 in urban areas (Brits, Hartbeespoort, and Skeerpoort, among others) and 21 in rural areas and villages (Lehotlha, 2015). The district has a population of 477,381, making it the second most populous municipality in the Bojanala District Municipality after Rustenburg. It is predominantly rural, with 57% of the population living in rural or traditional areas, 28% in urban areas, and 15% in farming areas. Setswana is the most spoken language. The population is slightly male dominated (53%), and there is a notable gender disparity among the elderly, with more than twice as many women as men aged 85 and older. People under 20 years old make up over a quarter of the population (33.5%), while those aged 65 and older constitute 5% (Lehotlha, 2015).

Sampling technique and sample size

The study adopted non-probability, purposive sampling techniques and recruited teachers who were teaching mathematics. Althubaiti (2022) defines the sample size (n) as the number of subjects to be included in a study from a population. Qualitative samples mostly require small samples (Indrayan & Mishra, 2021; Vasileiou et al., 2018). Rosenthal (2018) states that the qualitative sample size should be large enough to address the study phenomenon but sufficient as guided by saturation, which refers to the point in data collection when no additional insights are identified (Saunders et al. 2018). On the other hand, Keshoofy et al. (2023) argues that there is no consensus on the minimum sample size for qualitative studies, the keystones for qualitative sample sizes are data adequacy and saturation. Data begins to repeat on saturation so that further data collection is redundant, signifying an adequate sample size is reached. Therefore, in this study, saturation at the data collection stage determined the sample size ($n = 7$). That is, the researcher continued interviewing the teachers until no newer useful data emerged.

Data Collection

The research team first contacted the relevant senior staff at the schools to obtain relevant information about the number of mathematics teachers in the school. A list of teachers to be interviewed was provided. The local schools were consulted to set up dates for the interviews. The researchers then travelled to the schools where the teachers were to conduct in-depth face-to-face interviews and followed with online meetings for verification and validation of interview responses. Data were collected using a semi-structured interview guide.



The guide included questions related to participant demographics such as when did you qualify to be a teacher, gender, level of education, number of subjects overseeing (see Table 1). To better understand a teachers' challenges, the following listed in Table 2 were asked. Though straightforward as they sound, the guide was given to experts in the field for content validation and piloted before the actual data was collected.

Part A: Participant information

Table 1. Demographic Information

No.	Questions about participant demographics
1	Gender
2	What is your highest qualification?
3	When did you start as a qualified teacher?
4	How many subjects are you teaching?

Part B: Interview guide

Table 2. Structured Interview Guide

No.	Interview questions
1	What are the challenges that you face when you are teaching mathematics?
2	What are some of the teaching strategies you employ when teaching mathematics?
3	What contributes to mathematics underperformance?
4	How do you keep yourself updated with current educational trends?
5	Do you get form of support from school and Department of Education?
6	What is your view about parental involvement in school?
7	How do learners learn?
8	What demotivates learners to avoid taking mathematics and how can we improve that?

Data Analysis

Content analysis was used to analyse the structured interview responses. Content analysis determine the presence of themes, concepts and certain wording of words embedded within a text (Krippendorff, 1989; 2018). Cross validation of study results will be ensured by allowing other co-authors to carry out the analysis and then merge similar findings. Where divergence of results occurs, the researchers will discuss the diverging results to look for any missed or overlooked study finding during the analysis phase.

Ethical Considerations

This study was conducted with adherence to ethical standards, as approved by the Tshwane University of Technology Faculty of Humanities. Informed consent was obtained from all participants prior to their interviews, ensuring they were fully aware of the study purpose, and procedures. Participants were made aware of their right to withdraw at any time without any consequences. Confidentiality and anonymity were strictly upheld throughout the research process to protect the privacy of the participants. Data was securely stored and only accessible to the research team.

RESULTS AND DISCUSSION

Results

Demographic information

The study included seven mathematics teachers, comprising four males and three females. The highest qualification attained were Bachelor of Education ($n = 4$; 57.14%) and Honours ($n = 3$; 42.86%). About 71% of the participants had less than 10 years teaching experience. Only two (39%) were well experienced in teaching mathematics. Four (57.14%) teachers were responsible for overseeing three subjects, two (28.57%) oversaw four subjects, whereas one teacher (14.29%) oversaw six subjects, this highlights teacher overburdenedness and possible reasons for underperformance.

Challenges of teaching effectiveness in selected secondary schools

Teachers reported various challenges that impeded their effectiveness in teaching. Underpinned in Table 3, the most common challenges included lack of resources, congested annual teaching plan (ATP), learner content gaps, and learner ill-discipline. Additionally, overcrowded classrooms, lack of infrastructure, and unfamiliarity with mathematics were also highlighted.

Table 3. Challenges of teaching effectiveness

No.	Challenges faced by teachers
1	Demotivated learners
2	learner who does not practice
3	learners who are willing to not go extra mile
4	Lack of resources
5	overcrowded classrooms
6	lack of infrastructure and lack of funds
7	Congested ATP
8	Poor management
9	Subject content gaps
10	Ill-discipline from the learners
11	Subject coercion
12	Learners are not familiar with mathematics

One of teacher highlighted the issue of a congested ATP, stating, "*The most challenging aspect is the congested ATP. In term one, teachers are also responsible for extracurricular activities, which takes up a lot of time. This leaves minimal time to cover the required content. Additionally, content coverage becomes tricky when learners come from grade 9 without having adequately covered the ATP or the subject matter. Sometimes, learners are demoralized because they were taught by a teacher who didn't specialize in mathematics, leading to underperformance. Poor time management on the part of learners also poses a challenge, as they take a long time to complete even small tasks*".

Another teacher mentioned, "*Some learners lack necessary equipment like calculators. Learners in grade 10 often don't have the prerequisite knowledge because*

mathematics is marginalized in lower grades. As a result, we must start teaching the subject from scratch in grade 10. In township schools, maintaining learner discipline has become extremely challenging. Additionally, the number of learners keeps increasing, leading to overcrowded classrooms".

Table 4. Teachers' teaching strategies

No.	Teaching strategies
1	Group discussion
2	scaffolding content
3	weekly assessments
4	learner centeredness
5	Peer teaching
6	Make use of past papers
7	Relate the subject to real life scenarios
8	Introduce extra classes
9	Build on acquired knowledge
10	Give learners problems, and check which concepts still gives them a headache

The study also shed light on the teaching strategies employed by these teachers in their classrooms. Common strategies included group discussions, weekly assessments, and peer teaching. Interestingly, some teachers managed to relate the subject to real-life scenarios, introduced extra classes, and built on learners existing knowledge. *Additionally*, some teachers managed to apply strategies they had learned from their colleagues, including those from other peers.

One teacher highlighted the effectiveness of relating the subject to real-life business scenarios: *"The most effective strategy I use is constantly relating the subject to real-life business scenarios. I also conduct case studies related to each topic and introduce extra mural activities, such as morning and afternoon study sessions, to cover more material"*.

Another teacher emphasized building on learners existing knowledge and peer teaching: *"I check the knowledge that learners already have and build on that. I also use peer-to-peer teaching, where learners teach each other and learn from one another. Group discussions are another strategy I use, where learners help each other with questions they don't understand, and high-achieving learners assist their peers"*.

Interventions

Regarding teaching interventions, most teachers advocated for the early introduction of mathematics concepts and language. They emphasized the importance of inviting industry and academic experts for talks and career guidance. One teacher supported this by saying, *"We can solve this challenge by having real-life experiences where professionals in the field come and address the learners themselves."* Additionally, making mathematics practical and applicable to daily life was pinpointed as a crucial strategy.

Teachers also pointed out the issue of using non-specialist teachers to teach highly specialized subjects like mathematics. Additionally, they stressed the

importance of mathematics excursions, including field and experiential learning to institutions of higher learning and industry to align learners with their specific subjects and future aspirations. These excursions inspire learners by exposing them to professionals who have succeeded in the field with similar background. As one teacher noted, *"There is a lack of career exhibitions, especially in public schools. If there is a program, it is often conducted by people who do not know much about the field. As a result, learners are not exposed to the opportunities that studying mathematics can offer them"*.

Table 5. Mathematics teaching interventions in selected secondary schools

No.	How can we improve learner interest in Mathematics
1	introducing mathematics concepts in early grades
2	Get experts in the field to address learners
3	organizing mathematics excursions in mathematics related companies
4	Make mathematics more practical
5	avoiding assigning non-specialist teachers to teach mathematics
6	Engage parents in the studies of the learners

Discussion

The results of this study highlight several critical challenges faced by mathematics teachers in South African secondary schools, including demotivated learners, lack of resources, overcrowded classrooms, lack of infrastructure, poor management, congested annual teaching plan, and ill-discipline. These findings are consistent with recent literature that underscores the persistent educational inequalities in South Africa (Du Plessis & Mestry, 2019; Van der Berg & Gustafsson, 2019; to Letshwene & Du Plessis, 2021; Aguhayon et al., 2023). Demotivated learners remain a significant hurdle, as highlighted by Ferri et al. (2020) and Ahmad (2021), who emphasizes the importance of engaging teaching strategies to maintain student interest and motivation. The lack of resources, including textbooks and teaching materials, further exacerbates the difficulties faced by educators. According to several studies, adequate resources are essential for effective teaching and learning, and their absence can severely hinder educational outcomes (Lin, 2019; Chen & Xiao, 2021; Carrete-Marín & Domingo-Peñafiel, 2022; Vinnervik, 2022).

Overcrowded classrooms are another major issue confronting most government schools, leading to a high student-to-teacher ratio that inhibits individualized attention and effective classroom management. This challenge is echoed in the findings of (Khan & Iqbal, 2012; Mpu & Adum 2021; Osai et al., 2021; Zaman et al., 2023), who note that overcrowded classrooms can negatively impact student learning and teacher effectiveness. Similarly, the lack of infrastructure, such as proper classrooms and facilities, poses a significant barrier to providing a conducive learning environment (Mpu & Adum 2021; Palau et al., 2021; Azhari & Fajri, 2022). Additionally, poor management and ill-discipline further compound these challenges. Effective school leadership is crucial for creating a supportive and well-organized educational environment. According to several researchers, strong leadership and management

practices are essential for fostering a positive school culture and improving student outcomes (Bhakuni, 2022; Alademmerin, 2023; Fatimah et al., 2024).

Despite these challenges, the study also highlights the effective strategies employed by teachers to overcome these obstacles. For example, the use of scaffolding, weekly assessments, and past exam papers has been shown to enhance student understanding and retention of mathematical concepts (Rahma et al., 2020; Roshni & Rahim, 2020; Crisianita & Mandasari, 2022; Kruiper et al., 2022). Additionally, learner-centered approaches, including group discussions and peer teaching, which focus on active student participation and engagement, have proven effective in improving learner performance (Roshni & Rahim, 2020; Komatsu et al., 2021; Crisianita & Mandasari, 2022). Moreover, inclusion of cognitive and metacognitive strategies, such as connecting new knowledge to real-life experiences and fostering self-regulated learning (blended learning), has proven effective in navigating post-pandemic educational challenges (Du et al., 2022; Widjaja & Aslan, 2022; Ayob et al., 2023). These strategies are crucial in enhancing learner performance in mathematics and fostering critical thinking and lifelong learning skills.

The results of this study also highlighted several effective interventions that can enhance teaching mathematics. These interventions include introducing mathematics concepts in early grades, getting experts in the field to address learners, organizing mathematics excursions, making mathematics more practical, and avoiding assigning non-specialist teachers to teach mathematics. Introducing mathematics concepts in early grades is crucial for building a strong foundation. Several studies emphasize the importance of early exposure to mathematical concepts, which can significantly improve learners understanding and performance in later years (Papadakis et al., 2021; Humphreys & Parker, 2023; Tañola & Lomibao, 2024). Early intervention helps develop critical thinking and problem-solving skills, which are essential for learner success in mathematics.

Engaging experts in the field to address learners provides valuable insights and inspiration. According to multiple researchers, having experts share their knowledge and experiences can motivate learners and provide them with a deeper understanding of the subject (Sriratanaviriyakul & El-Den, 2017; Sriratanaviriyakul & El-Den, 2019; Hosen et al., 2021). This approach bridges the gap between theoretical knowledge and real-world applications, making mathematics more relevant, relatable and engaging for learners. Furthermore, mathematics excursions on the other hand offer learners hands-on learning experiences that reinforce their understanding of mathematical concepts. These excursions provide platforms for learners to see the practical applications of mathematics beyond the classroom in various fields, such as health, finance, and information technology. Several studies highlight that experiential learning through excursions significantly improves student engagement and retention of mathematical concepts (Palia, 2020; Kong, 2021; Rugaiyah, 2022).

Making mathematics more practical by incorporating real-world applications and hands-on activities can also enhance student engagement and understanding. Various researchers highlight that the benefits of integrating practical examples and

interactive activities into mathematics lessons makes mathematics more practical (Uyen et al., 2021; Wijaya et al., 2021; Biber et al., 2022; Viberg et al., 2023). This approach helps learners see the relevance of mathematics in their daily lives and fosters a more positive attitude towards the subject. Lastly, avoiding the assignment of non-specialist teachers to teach mathematics is another critical intervention. Research by Crisan and Rodd (2017) and Van Putten et al. (2022) indicates that non-specialist teachers often lack the necessary content knowledge and pedagogical skills to effectively teach mathematics. Ensuring that mathematics is taught by qualified and specialized teachers has potential to improve the quality of instruction and learner performance.

Implications For Practice

The study's findings highlight several key implications for practice relevant to the South African education context. Addressing resource constraints is crucial, as a lack of resources derails teaching effectiveness. Secondary schools should ensure teachers have adequate teaching materials and proper infrastructure conducive for learning. Revising the annual teaching plan to allow sufficient time for curriculum coverage and new teaching strategies is crucial for student success. Additionally, it is important to motivate and engage learners through learner-centered approaches, gamification, and blended learning, this can improve learner enthusiasm and discipline. Promoting collaboration between schools, industry, and government can further enhance teaching effectiveness through professional development and resource sharing. Furthermore, emphasizing formative assessment and diversifying teaching pedagogies, including underutilized methods like gamification, can cater to diverse learner needs and improve the prolonged educational inequalities. Implementing these strategies will help overcome challenges and improve government school mathematics education.

CONCLUSION

This study highlighted the multifaceted challenges, strategies and interventions in teaching effectiveness. Through in-depth interviews, we uncovered significant obstacles such as insufficient resources, congested annual teaching plans, demotivated learners, ill-discipline, and subject coercion. These hindrances are deeply rooted in the broader educational imbalances inherited from the apartheid regime. Despite these hurdles, government schoolteachers remained resilient, creative and shine through. They were able to implement effective strategies like scaffolding, weekly assessments, past exam papers, and learner-centred approaches to enhance learner performance. These practices not only alleviate immediate educational inequalities but also foster a more engaging and supportive learning environment.

The findings of this study underpin the urgent need for robust support and adequate resources for teachers. Additionally, collaboration among government bodies, school heads, and principals is important to provide the necessary support and



resources, thus improving student outcomes and reducing dropout rates. To address these issues effectively, we recommend increasing resource allocation to ensure schools are adequately funded, offering continuous professional development programs for teachers. Also, advocating for policy reforms to address the post-apartheid systemic inequalities, fostering stronger partnerships between schools and communities. Implementing regular monitoring and evaluation of teaching practices and student performance to avoid hiccups. By drawing attention to these critical issues and proposed recommendations, we hope to inspire a concerted effort from all stakeholders to support teachers and create an environment conducive to learner excellence.

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