

 Research Article

Exploring Pedagogical Practices in Mathematics Education

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Abstract

This study aimed to investigate effective teaching strategies in mathematics education through a multi-method qualitative approach. Data were collected from two purposefully selected secondary schools, involving classroom observations, interviews with two mathematics teachers, and document analysis. The research sought to provide a comprehensive understanding of the teachers' instructional methods, drawing on various data sources to explore how these methods influence student learning and engagement. In-depth interviews with the teachers provided rich insights into their beliefs, experiences, and motivations regarding mathematics education. These interviews allowed the teachers to reflect on the challenges they face, the factors shaping their teaching practices, and their strategies for engaging students. Classroom observations captured the day-to-day dynamics of teaching, offering a real-time view of how the teachers applied pedagogical techniques, managed classrooms, and interacted with students, while also highlighting the level of student participation and attention. Additionally, the study analyzed instructional materials, lesson plans, and assessments to assess how well the teachers' practices aligned with curriculum objectives and educational standards. The findings revealed different approaches to mathematics instruction, revealing both the strengths and limitations of the methods employed. This research contributes to the growing body of knowledge on mathematics pedagogy in public secondary schools, offering valuable insights for future improvements and further research into enhancing teaching practices in the classroom.

Keywords: Mathematics Education, Pedagogical Practices, Public Secondary Schools

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1. INTRODUCTION

Mathematics education is a critical component of the secondary school curriculum, and the pedagogical practices employed by teachers play a significant role in shaping students' understanding and achievement in mathematics subject. By examining the teaching methods, strategies, and approaches employed by teachers, the researchers pursued to gain insights into the factors influencing their instructional decisions and the influence of these practices on student learning outcomes.

The choice of two public secondary schools as the focus of this study was considered, as it reflected the variety and complexity of the educational countryside, particularly in urban settings. The study intended to get on on an exploratory ride, investigating into the pedagogical practices of mathematics education in two public secondary schools in Rwanda.

By conducting a qualitative study focused on the experiences of two experienced mathematics teachers, the researchers tracked to reveal the strategies, challenges, and innovations that shape the learning environment for secondary school students in Rwanda. Additionally, understanding the pedagogical

practices in these schools helped to inform educational policymakers, administrators, and other stakeholders about effective strategies to enhance mathematics education.

Through in-depth interviews, classroom observations, and analysis of teaching materials, the study provided a comprehensive exploration of the pedagogical practices of the selected mathematics teachers.

1.1. Literature Review

1.1.1. Pedagogical Practices in Mathematics Education

Mathematics education is a critical component of secondary schooling, as it equips students with essential analytical and problem-solving skills. Mathematics education at the secondary school level plays a crucial role in equipping students with essential skills and knowledge for their future academic and professional pursuits. Effective pedagogical practices in mathematics instruction are vital to promote students' understanding and helpfulness for the subject.

In recent years, there has been a growing interest in understanding the pedagogical practices employed by mathematics teachers in public secondary schools. Recent research has shown a growing trend in the integration of technology and blended learning approaches in mathematics education. Yao and Zhao (2022) emphasize the positive impact of online resources, interactive software, and digital platforms in enhancing mathematics instruction. Traditional methods involve teacher-centered instruction, where the teacher presents concepts and students passively receive information as mentioned by Hiebert and Grouws (2007) have found that this approach limit students' engagement and deep understanding of mathematical concepts. They also indicated that Traditional teaching methods have long been the cornerstone of mathematics instruction in secondary schools. These methods typically involve teacher-centered lectures, textbook-based learning, and rote memorization. While these practices offer structure and consistency, they often fail to engage students actively and promote deep understanding (Niyibizi, 2024).

The study has highlighted a shift away from traditional teacher-centered instruction toward more student-centered approaches. This includes problem-based learning, inquiry-based learning, and flipped classrooms, within Deringöl and Davaslıgil (2020) have explored how personalized learning experiences cater to various student needs, raising a deeper understanding of mathematical concepts. Furthermore, they said that Differentiated instruction improves teaching strategies to accommodate students' different learning needs and abilities. In the context of mathematics education, this approach involves providing varied materials, tasks, and support to meet individual students' needs. Their study also has shown that differentiated instruction improves student performance and engagement in mathematics.

The integration of technology, such as interactive whiteboards, educational software, and online resources, has become increasingly prevalent in mathematics classrooms (Polly, et al., 2022). They also indicated that the integration of technology, such as graphing calculators, computer software, and online resources, has transformed mathematics education. Furthermore, they also indicated that technology provides opportunities for dynamic and visual learning.

According to Suhendi et al. (2021) indicated that the constructivist pedagogical practices emphasize active engagement, collaborative learning, and problem-solving. In mathematics education, constructivist methods involve tasks that encourage students to explore mathematical concepts, work together on real-world problems, and construct their understanding (Suhendi et al., 2021). Their study suggested that constructivist approaches enhance students' conceptual understanding, mathematical reasoning, and problem-solving skills. Moreover, their study also engaged that inquiry-based learning encourages students to ask questions, investigate mathematical phenomena, and determine solutions independently. This approach promotes curiosity, creativity, and a deeper understanding of mathematical concepts.

Classroom observations have emphasized the need for formative feedback and professional development for mathematics teachers. Deng et al. (2020) demonstrated how continuous classroom observations enhance pedagogical practices by identifying areas for improvement. Classroom observations continue to be a valuable method for capturing real-time pedagogical practices.

Ensuring that all students, regardless of their background, benefit from innovative pedagogical practices was a priority. Traditional assessments may not align with new pedagogical practices, requiring a

revision of assessment strategies. Implementing innovative pedagogical practices in mathematics education may face resistance from teachers familiar to traditional methods. This updated literature review provided insights into the evolving of pedagogical practices in public secondary school mathematics education. The shift towards student-centered learning, the integration of technology, and the importance of differentiated instruction and inclusion were key trends. Methodologically, classroom observations, semi-structured interviews, and document analysis remained essential tools for investigating these practices. Recent study has investigated into teacher beliefs, professional development, assessment strategies, and the impact contributing to a more comprehensive understanding of mathematics education in two secondary schools based on the following research objective: To explore the influence of various pedagogical practices on students' learning outcomes and attitudes towards mathematics in public secondary schools.

1.1.2. Theoretical Groundwork

Constructivist Perspective, this theory suggests that students actively construct their own understanding of mathematical concepts through interactions with their environment, peers, and teachers. In this context, pedagogical practices should be student-centered, focusing on promoting students' active engagement, problem-solving skills, and critical thinking in mathematics. Also, socio-cultural perspective, this theory emphasizes the importance of social interactions and cultural context in the learning process. It suggests that mathematics learning is not an isolated activity but occurs within a social and cultural context. Pedagogical practices should consider the cultural backgrounds, experiences, and social interactions of students, aiming to make mathematics more meaningful and relevant to their lives. Therefore, combining these two perspectives, the suggested theories for exploring pedagogical practices was based on a constructivist approach that encourages students to actively construct their mathematical understanding through problem-solving and critical thinking. It also considers the sociocultural background of students, acknowledging the significance of their social relationships and cultural backgrounds in influencing their mathematics learning experiences. By integrating these perspectives, teachers created a more inclusive and engaging mathematics education environment, promoting deeper understanding and higher achievement among students.

2. METHODS

2.1. Research Design

This study was especially well-suited for a qualitative research technique as it made it possible to collect data, document teachers' real-world experiences, and comprehend the complex dynamics influencing mathematics education in secondary schools in Rwanda. Through the lens of qualitative research, this study was employed a qualitative research approach to explore pedagogical practices in two public secondary schools in mathematics education. Qualitative research was suitable for gaining in-depth insights into teachers' pedagogical practices and their experiences.

2.2. Research Participants

The present study was involved two mathematics teachers (Teacher A and Teacher B) from different public secondary schools (school X and school Y). The selection of participants was based on their willingness to participate and their consent.

2.3. Data Collection

The data collection process within this research was designed to be complete. It involved a combination of approaches to ensure a comprehensive understanding of the teachers' pedagogical approaches. Interviews, classroom observations, and document analysis were the key tools employed. Through in-depth interviews with the selected mathematics teachers, the researchers aimed to gain insight into their beliefs, motivations, and strategies for teaching mathematics. Also, classroom observations offered a real-time sight into the dynamics of the teaching-learning process, while document analysis

examined curriculum materials, textbooks, and assessment tools. Therefore, the data collection efforts were rooted in the cultural, social, and institutional fabric of Rwanda's public secondary schools. The researchers conducted classroom observations of the two teachers over a period of four weeks. Detailed notes were taken on teaching strategies, student engagement, and classroom dynamics. Also, the researchers conducted semi-structured interviews with the two teachers to gain insights into their teaching philosophies, instructional methods, and challenges faced. Additionally, relevant documents such as lesson plans, curriculum materials, and student assessments were being analyzed to understand the context of mathematics education in each school.

2.4. Data Analysis

Qualitative data analysis techniques, particularly thematic analysis, were central to take out the rich, data collected in the study. Thematic analysis provided a structured approach to identify, analyze, and interpret patterns within the data. This method enabled the researchers to focus on recurring ideas and insights related to pedagogical practices, challenges, and effective strategies in the classroom. Classroom observation notes and interview transcripts formed the primary data sources for the analysis. The observational data offered a detailed account of teaching strategies and classroom dynamics, providing context and depth to the study's findings. Simultaneously, interview transcripts captured the voices of teachers and students, shedding light on their experiences, perceptions, and challenges.

Emerging themes highlighted significant aspects of effective teaching practices, including innovative strategies that raised student engagement and learning outcomes. By categorizing these themes, the analysis not only offered insights into current practices but also provided a foundation for recommending practical, evidence-based strategies for improving classroom instruction. This thorough qualitative approach ensured that the study's findings were grounded in real-world experiences and aligned with the research objectives.

2.5. Ethical Considerations

Ethical approval was obtained from relevant authorities and school administrations. Additionally, informed consents were obtained from the participating teachers, and their identities were kept confidential.

2.6. Validity and Reliability

Triangulation was used to validate the findings by comparing data from classroom observations, interviews, and document analysis. Member checking was also being conducted to ensure the accuracy of the interpretation.

2.7. Limitations and Timelines

Firstly, it was imperative to acknowledge that qualitative research integrally involved a smaller sample size. The study focused on only two teachers from public secondary schools in Rwanda. Although this restriction has limited the findings' applicability to a larger population, Secondly, the timeline of this study was constrained by practical considerations. Conducting qualitative research involved extensive data collection, transcription, and analysis, all of which required a substantial amount of time and resources. Despite these limitations, the researchers remained committed to delivering a rigorous and insightful study that contributes to the discourse on mathematics education in Rwanda. Therefore, this study has limitations related to the generalizability of findings as it focused on two specific teachers in two different schools. The findings may not represent the entire population of mathematics teachers in public secondary schools in Rwanda. The study was conducted over a period of six months, including data collection, analysis, and report writing.

3. RESULTS

During classroom observations of teachers, teacher A, it was observed that the teacher primarily used traditional teaching methods, such as talks and worksheets, to deliver mathematical content. The teacher rarely incorporated technology or real-world examples in the lessons. The students were often passive learners, listening to the teacher and working individually on assigned tasks. There was minimal student interaction or collaborative learning in the classroom. Student engagement is relatively low, with few opportunities for students to actively participate or ask questions. The teacher primarily uses direct instruction and spends a significant amount of time at the front of the classroom. The classroom environment is teacher-centered, with limited student collaboration and discussion. In dissimilarity, Teacher B employed a more student-centered approach. Teacher often used group work and collaborative activities to encourage active participation among the students. During one observation, students were divided into small groups and given a real-world problem to solve. The lessons often included real-world examples and problem-solving tasks that required students to work in pairs or small groups. Teacher circulated among the groups, providing guidance and support as needed. Students were encouraged to work together, share their ideas, and solve problems collaboratively. Student engagement was at high, with active participation from most students. Teacher employed a student-centered approach, encouraging active participation and collaboration. The classroom had a more relaxed and open atmosphere, raising student engagement and discussions. This approach promoted student engagement and critical thinking skills.

The interviews with the two teachers provided valuable insights into their pedagogical practices and beliefs about mathematics education. In the interview with Teacher A, the teacher expressed a belief in the importance of covering the curriculum and preparing students for standardized tests. Teacher A voiced the following clarification,

"I'm a strong advocate for the idea that focusing on curriculum coverage is not only about meeting educational standards but also about empowering our students to outshine in standardized assessments and achieve their academic goals".

Teacher admitted feeling pressure to meet specific content goals and follow a prescribed curriculum, which limited the flexibility in teaching methods. The teacher also mentioned concerns about students' motivation and engagement in mathematics. The teacher felt that the lecture-based approach is the most effective way to convey the required content. Teacher A said with voice that,

"I firmly believe that the lecture-based approach is the most effective way to convey the required content. It allows for direct communication and in-depth explanation of complex topics".

Teacher believed that a lecture-style approach was the most effective way to achieve this goal. Teacher also felt pressure from the school administration to ensure high test scores. Teacher acknowledged that student engagement could be improved but struggles to find alternative teaching methods. On the other hand, teacher B emphasized the significance of raising a deeper understanding of mathematical concepts and developing students' problem-solving skills. Teacher B stated clearly that,

"It's essential to emphasize the significance of raising a deeper understanding of mathematical concepts and developing students' problem-solving skills".

Teacher valued student engagement and critical thinking, acknowledging that not all students learn the same way. The teacher expressed a passion for teaching mathematics and highlighted the benefits of using technology and real-world applications in the classroom. With voice, Teacher B stated,

"By integrating technology into my lessons, I aim to bridge the gap between theory and practicality, showing students that mathematics is not just an abstract concept but a vital tool for success in the real world".

Teacher emphasized the importance of developing students' problem-solving skills and mathematical thinking. Voiced teacher B stated,

“The ability to develop strong problem-solving skills and nurture mathematical thinking in students not only enhances their academic performance but also empowers them to become more analytical, innovative, and confident individuals in all aspects of life”.

Teacher also discussed the importance of student collaboration and active engagement in the learning process. Teacher stressed the importance of understanding mathematical concepts rather than rote memorization, flexibility in teaching approaches was highlighted, with a willingness to adjust lessons based on student needs, and teacher values student engagement and believes that a student-centered approach raises a deeper understanding of mathematics. Teacher B said clearly the following,

“It is crucial to emphasize the significance of acquisitive mathematical concepts instead of resorting to mere rote memorization, as this approach allows students to build a solid foundation for problem-solving and critical thinking”.

The teacher was open to adapting their teaching methods based on students’ needs and interests and recognized the challenges of managing a student-centered classroom. Teacher B emphasized the following using voicing,

“One of the key challenges of managing a student-centered classroom is ensuring that all students are actively engaged and taking ownership of their learning”.

On the other hand, teacher A clarified the following with voice,

“In a student-centered classroom, it’s a challenge to maintain a supportive and inclusive learning environment, particularly when dealing with varying levels of student independence and self-discipline”.

Furthermore, teacher B believed that students should not just memorize formulas but understand the underlying concepts. With voicing, Teacher B pointed out,

“In mathematics, the goal should be more than just formula memorization; true proficiency comes when students have a solid foundation in the underlying concepts, allowing them to solve a wide range of problems”.

The analysis of curriculum documents for both schools revealed a focus on content coverage and alignment with standardized testing. However, Teacher B demonstrated more flexibility in adapting the curriculum to meet students’ needs and interests. Lesson plans incorporated a variety of resources, including interactive software and real-world applications. Assessments included open-ended questions assessments that required critical thinking and problem-solving skills. The curriculum was more flexible, allowing for student input and exploration of mathematical concepts. Teacher A adhered more rigidly to the prescribed curriculum. Lesson plans and instructional materials mainly consist of traditional worksheets and textbooks. Assessments primarily focused on multiple-choice questions and formulaic problem-solving. The curriculum followed a linear progression, with limited room for exploration or creativity.

4. DISCUSSION

The data findings from classroom observations, semi-structured interviews, and document analysis highlighted significant differences in pedagogical practices between Teacher A and Teacher B in the context of mathematics education in public secondary schools. Teacher A adhered to a traditional teaching approach, emphasizing content delivery through lectures and textbooks. Teacher A’s traditional teaching methods and focus on content coverage may limit students’ opportunities for active engagement and deeper understanding of mathematical concepts. However, teacher B adopted a more student-centered approach, promoting active engagement, collaboration, and practical application of mathematical concepts, use of technology, and emphasis on real-world applications create a more interactive and collaborative learning

environment. The findings also suggested that Teacher B's flexibility in adapting teaching methods to provide to different learning styles aligns with contemporary educational theories that prioritize student-centered learning. Teacher A's rigid adherence to traditional methods may need reconsideration to enhance the quality of mathematics education in public secondary schools. The semi-structured interviews indicated that Teacher A's approach is driven by the pressure to meet curriculum requirements and standardized testing demands. Teacher A appeared to be aware of the limitations of their teaching style but struggles to deviate from it. On the other hand, Teacher B prioritized student engagement and values the benefits of a student-centered classroom, even though it presents challenges in classroom management. Document analysis supported the observed practices, with Teacher A relying on traditional instructional materials and assessments, while Teacher B incorporated a more different range of resources and assessments that align with a student-centered approach.

The current findings align with the Constructivist and Socio-Cultural perspectives on learning. Constructivism posits that students build their understanding of mathematical concepts through active engagement with their surroundings, peers, and teachers, emphasizing the need for student-centered teaching practices that raise problem-solving, critical thinking, and deeper engagement. In parallel, the Socio-Cultural theory highlights the role of social interactions and cultural context in shaping the learning experience, suggesting that mathematics learning is inherently social and contextual, shaped by collaborative discussions, shared experiences, and the cultural tools available within the learning environment. Both perspectives advocate for a holistic approach where students' interactions within and outside the classroom play a pivotal role in their understanding and application of mathematical knowledge.

The results are consistent with work by Deng et al. (2020), which showed how regular classroom observations may improve instructional techniques by highlighting potential improvements. The results support Yao and Zhao (2022) affirmation that technology, interactive software, and online resources improve mathematics education. Furthermore, the results are in accordance with those of Polly, Martin, and Byker (2022), who noted that the use of internet resources in mathematics classes has grown. Meanwhile, the results are consistent with Suhendi et al. (2021), who noted that constructivist pedagogical techniques place an emphasis on problem-solving abilities, collaborative learning, and active involvement.

5. CONCLUSION

The findings suggested that pedagogical practices in mathematics education vary significantly between teachers within the same school. Teacher beliefs, external pressures, and willingness to adapt play a crucial role in shaping these practices. The study sheds light on the importance of pedagogical practices in mathematics education and their impact on student learning experiences. It highlights the need for teachers to adopt more student-centered approaches, incorporate technology and real-life examples, and prioritize conceptual understanding over memorization in order to improve mathematics education in public secondary schools. Further research is needed to explore the impact of these pedagogical approaches on students' mathematical achievement and motivation. In order to support good teaching methods, it is also important to look at the elements that affect instructors' instructional decisions.

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Declaration Statements. The authors affirm that this research was conducted with integrity and in adherence to ethical standards. All data, findings, and conclusions presented in this article are original and accurately reported.

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