The Rural Educator

Volume 46 | Number 3 | Article 4

Summer 7-2025

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Recommended Citation

Mbhiza, H. W., & Nkambule, T. (2025). Understanding Grade 10 Learners' Mathematics Learning Experiences in Rural Schools: Applying the Self-Determination Theory. *The Rural Educator, 46*(3), 29-42. https://doi.org/10.55533/2643-9662.1429

International Research Article

Understanding Grade 10 Learners' Mathematics Learning Experiences in Rural Schools: Applying the Self-Determination Theory

Hlamulo Wiseman Mbhiza and Thabisile Nkambule

The increasing performative expectation in mathematics continuously positions rural learners in a deficit manner within the education system in post-apartheid South Africa. The often-cited low academic performance of rural learners in mathematics fosters the belief that something is wrong with their mathematical learning abilities. The problem with narrow and often decontextualized perspectives of rural learners is that their interactions with mathematical content are frequently overlooked in education research. The purpose of this study was to critically explore grade 10 rural learners' mathematics learning experiences. We employed a qualitative descriptive approach within a case study design, using semi-structured individual interviews supported by unstructured classroom observations to explore and understand learners' mathematics learning experiences. The findings indicate that multidimensional constructs and introjected regulations play a role in these learning experiences. Overall, learners' mathematics learning experiences in this study were not solely determined by the teaching and learning context, but by agentic engagement and introjected regulation.

Mathematics is an integral part of the curriculum globally, including in South Africa, where it is compulsory until grade 9 to expose learners to mathematics before they leave secondary school (Jojo, 2019). The process of learning mathematics is always demanding, as the nature of the subject imposes high conceptual demands on learners. According to Akhter and Akhter (2018), mathematics involves procedures that may appear abstract and unrelated to everyday life, and it is considered one of the more difficult subjects. Similarly, Mariamah et al. (2020) noted a widespread belief among learners that mathematics is challenging; some learners opt out whenever possible, while others choose to remain and self-regulate despite their struggles, as it is considered a gateway subject to postsecondary education and the job market. The latter group of learners represents self-determination, as they possess a belief in their own abilities (Habibi et al., 2018). Earlier, Deci et al. (2013) stated, "When a behaviour is self-determined, the intentional regulation process is choice" (p. 112). It is this idea of choice, alongside the status of mathematics, that encourages some learners to persevere in secondary school.

While the process of learning mathematics is considered demanding, there is a dearth of research on rural schools and their mathematics learners. Previous research has focused on townships and former model C[1] secondary schools, and rural schools continue to be underresearched, although South Africa is predominantly rural (van Schalkwyk et al., 2014). The objective of this study was to understand grade 10 learners' experiences of mathematics learning and the motivations that influence this learning in a dynamic rural context. To achieve this objective, the research question was: How do grade 10 rural learners experience mathematics learning? This study contributes alternative perspectives on the often overlooked mathematics learning experiences of learners in rural secondary schools.

Understanding Rurality and Rural Education Research

Researchers (Agumba, 2020; Green & Reid, 2014; Halfacree, 2006; Nkambule, 2017) agree that rurality is a contested concept, and Stelmach (2017) concludes that "rural" is conceptually evasive due to the absence of a universal meaning. Soudien et al. (2019) argue that rurality, like poverty and inequality, is not pregiven but is the result of complex forces, which means it is not always appreciated for its own sake. It does not always constitute a form of disadvantage, traditionalism, or backwardness (Leibowitz, 2017). Rather, people in rural areas are resilient and determined despite constraints, not positioned as deficient (Randall et al., 2015). While Green and Reid (2014) extrapolate that rural areas are often positioned as deficient rather than as different

[1] Former model C schools refer to schools designated for Whites during apartheid, admitting learners of all races post-apartheid.

and are frequently imagined as residual spaces outside the boundaries of modernity, Mngomezulu (2020) posits that rurality, as a phenomenon, is irrefutably one of the characteristic features of much of the African continent. For example, in Zimbabwe, 62% of the population resides in rural areas, making it a highly ruralized country (Magidi, 2024), and in South Africa, 64% of the population is rural (Ebersöhn & Ferreira, 2012). The South African government views rurality as "a way of life, a state of mind, and a culture that revolves around land, livestock, cropping, and community" (Hlalele, 2014, p. 462). Recently, Minister of Basic Education Motshekga (2019), stated,

> As a country, South Africa is considered to have immense inequalities and socio-economic challenges, which are most intense in rural areas. Because rural landscapes and schools are unique, the nature of schools in rural South Africa is seen as "nodes of development" in a real sense. (p. 6)

It has not been easy for the Department of Basic Education (DBE, 2017) to define rurality. They explained,

> "rural" refers to areas that consist of tribal lands controlled by traditional leaders, as well as agricultural areas, which are some of the major means of economic activity. The concept also includes areas of dense settlement created by colonial and apartheid-driven land settlements, as well as mining areas in rural contexts where mining is no longer active. (p. 9)

In South Africa, rural encompasses areas characterized by low population density, limited access to essential services, and a reliance on agriculture and natural resources for livelihoods (Nkambule, 2017). Rural regions and schools often face significant socioeconomic challenges, including high levels of poverty, unemployment, and inadequate infrastructure, which contribute to disparities in health, education, and overall quality of life compared to urban areas (Ngwenya et al., 2023). Moreover, rural communities in South Africa are marked by unique cultural identities and social dynamics, where traditional practices coexist with modern influences, reflecting a complex interplay of resilience and adaptation among their inhabitants (Mngomezulu, 2020). We posit that rurality is not merely a geographical designation but encapsulates a complex interplay of cultural, economic, and social dimensions, reflecting the lived experiences of rural learners and their motivations for education.

The schools in rural areas have limited and small budgets at their disposal and can hardly afford to employ temporary teachers to ease the burden of heavy teaching workloads or secure other educational resources and additional finances (Boix et al., 2015). Working conditions in rural contexts are often unfavorable for teachers, who frequently must travel long distances from home to school, resulting in fatigue upon reaching their schools (Khumalo & Mji, 2014; Ngwenya et al., 2023). According to Dekeza and Kufakunesu (2017), most rural secondary schools lack laboratories, which hampers the effective teaching of science, technology, engineering, and mathematics (STEM) subjects. Shahnaz and Gandana (2020) further address STEM challenges, stating that teaching in rural schools has become increasingly difficult for educators due to obstacles such as language limitations imposed by rural dialects, a lack of teaching resources, inadequate school infrastructure, and cultural practices. To ensure effective teaching and learning, teachers also struggle to access support services, with few opportunities to attend inservice courses and access teacher-support materials and textbooks (du Plessis & Mestry, 2019).

Mushunje (2017) suggests that rural education is not adequately resourced to allow for the provision of quality service delivery, particularly evident in STEM subjects, information and communication technologies (ICTs), and all the technology-driven aspects of the curriculum. Communities can hardly afford resources to provide library services, which are critical at high school level for higher education preparations. In some rural schools, the government has installed whiteboards and overhead projectors without training teachers to integrate the technologies with their pedagogies, which means they become "white elephants" as they deteriorate in the classrooms. Such technology needs electricity and quality, stable internet connectivity, which are serious challenges in rural schools, along with the complexity of "loadshedding"[2] in South Africa. Generators are expensive, as are internet connections for teaching and learning. This situation calls for a move beyond representing rurality with a deficit paradigm and seeing it as dynamic and generative (Balfour et al., 2008). In the current study rural

[2] Loadshedding refers to the deliberate action taken by Eskom, the electricity supplier in South Africa, to implement rolling power blackouts to reduce the load on the national power supply during periods of high electricity demand in specific regions.

learners demonstrated self-determination to learn and own mathematical knowledge within multiple deprived contexts.

Literature Review

International Research on Mathematics Learning in Schools

According to Angelo and Legarde (2022), mathematics is the language that describes ideas and relationships derived from the environment, enabling learners to solve problems that would otherwise be impossible. It is crucial for learners to have a strong foundation in mathematics, which requires more than rote memorization of procedural knowledge (Lambdin, 2003). Learners' engagement in learning allows them to "actualise their identity through participation in activities situated in a specific context" (Op 't Eynde et al., 2006, p. 194). Similarly, Ayele and Dadi (2016) discuss the importance of learners' levels of engagement in mathematics, which refers to their active involvement and commitment to achieving educational goals.

Learners' engagement, according to Chiu (2022), is a construct comprised of four dimensions: behavioral, cognitive, emotional, and agentic. These dimensions are important for mathematics learning. Behavioral engagement refers to how involved learners are in learning activities in terms of attention, participation, effort, and persistence. Cognitive engagement refers to how much mental effort learners spend in completing learning tasks, in terms of using sophisticated rather than superficial learning strategies (Chiu, 2022). Emotional engagement refers to the feelings learners have toward teachers, peers, learning activities, and the school experience, as well as their sense of belonging (Sinatra et al., 2015). Agentic engagement is defined as the act of taking initiatives that constructively contribute to the learning processes (Reeve, 2013).

To identify what shaped learners' mathematics learning experiences inside and outside the classrooms, we considered these dimensions during our data analysis. We assumed that the manner of engaging with mathematics learning in grade 10 is an outcome of internal and external motivational processes that encourage learners to actively engage in mathematics learning activities (Reeve, 2013). In our interactions with the learners, we listened to their reflective explanations of mathematics learning experiences, as prior research (Acharya, 2017; Schleppenbach et al., 2007) has noted the importance of encouraging learners to explain and justify their mathematical ideas to develop higher-order thinking. This way of thinking in mathematics is linked with both external and internal motivation, and Adamma et al. (2018) contend that "intrinsic motivation is an inner force that motivates students to engage in academic activities, because they are interested in learning and they enjoy the learning process as well" (p. 53), irrespective of the contextual background. Thus, when learners put their heads together rather than work in isolation, they are more encouraged and responsive to challenging mathematics tasks.

Status of Mathematics Learning and Performance in South Africa

Following concerning struggles in the 2003, 2011, and 2015 Trends in Mathematics and Science Study (TIMSS) assessments, according to the 2019 results, South Africa has witnessed some improvements in grade 9 learners' mathematics performance (Reddy et al., 2020). Minister of Basic Education Motshekga expressed concern when presenting the 2019 TIMSS performance, noting that South Africa continued to be among the five lowest-performing countries (DBE, 2022, p. 5). Regarding the overall grade 9 mathematics results, the minister stated, "this implies that 59% of learners had not acquired basic mathematical knowledge, meaning that South Africa still has a way to go to improve mathematics basic knowledge" (Motshekga, 2019, p. 8). Relevant to the context of this article, Reddy et al. (2020) noted that the data showed "the only significant changes observed were decreases in learners' performance in Mpumalanga schools" (p. 10). While TIMSS assessed grade 9 learners, they became grade 10 learners the following year, without acquiring the basic mathematical knowledge described by the minister. In this context, we interacted with grade 10 rural learners in part of the Mpumalanga province to understand their mathematics learning experiences and their motivations for mathematics learning.

One of the aims of the DBE's Curriculum and Assessment Policy Statement (CAPS) is "to produce learners that are able to work effectively as individuals and with others as members of a team; manage and organise themselves in handling their activities responsibly and effectively" (DBE, 2011, p. 5). While we resist a deficit thinking model regarding rural areas and schools, rural communities have been identified as representing a high percentage of underperforming schools (Jojo, 2019). In this study, we align with Moletsane's (2012) argument that we must move beyond deficit paradigms about rural areas and adopt strength-based epistemologies, which recognize that rural individuals and groups possess strengths, skills, knowledge, and resources that can be harnessed to develop and implement interventions for social change (p. 1).

Research on Motivation in Mathematics Learning

Recent literature on motivation in mathematics learning highlights its multifaceted nature and significant impact on learner performance and engagement (Arthur et al., 2022). Mbhiza (2024) emphasizes that motivation in mathematics learning not only directly influences performance but is also mediated by learner interest, suggesting that fostering positive motivation can enhance engagement in mathematics. Similarly, Wahjuningsih et al. (2023) explore the relationship between teaching methods and learner motivation, asserting that motivation is a critical influence on learners' persistence and engagement in mathematics learning. Heffernan et al. (2020) contribute to this discourse by examining how mathematics identities can motivate learners, indicating that teachers can play a pivotal role in shaping positive mathematical identities that enhance motivation and learning outcomes.

In the current study, we contend that when learners are motivated, their engagement in mathematics learning increases, despite the challenges posed by rural realities such as a lack of adequate learning and teaching resources. In addition, research by Wang et al. (2018) reveals that the interplay between mathematics anxiety and motivation is complex, suggesting that understanding learners' emotional responses is crucial for fostering a supportive learning environment. Adhikari (2020) highlights the importance of intrinsic motivation, noting that personal interest significantly influences learners' choices in elective subjects related to mathematics. Other studies advocate for investigating the role of self-efficacy in learners' motivation (Thapa & Paudel, 2021; Liu et al., 2020), indicating that social factors and support systems are crucial for enhancing self-efficacy and, consequently, motivation in mathematics. Specifically, Liu et al. (2020) found that self-educational aspirations positively predict mathematics achievement, emphasizing the role of motivation in academic success. We observed this form of motivation in the current study.

Self-Determination Theory (SDT)

Self-determination theory (SDT) defines intrinsic and extrinsic sources of motivation and further assumes an inherently active individual, finding and following intrinsic motivations in the process of learning and developing knowledge (Ryan & Deci, 2017, 2020). A personal sense of control is important in SDT because it is an initiator of one's own activities, allowing the opportunity to make one's own choices, as the individual is self-propelled to act and has agency in their own performance (Kosko, 2015). SDT defines intrinsic and extrinsic sources of motivation and further assumes an inherently active individual, finding and following intrinsic motivations in the process of learning and developing one's knowledge (Ryan & Deci, 2017). A personal sense of control is important in SDT because it is an initiator of one's own activities, providing the opportunity to make one's own choices. The individual is self-propelled to act and has agency in their own performances (Kosko, 2015). In this study, we understand that learning mathematics relies on proactive learners who take initiatives and solve mathematics problems differently, with the intention of developing one's knowledge rather than finding the correct answers.

SDT posits that motivation exists along a continuum of autonomy, comprising four major subtypes of extrinsic motivation: external regulation, introjected regulation, identified regulation, and integrated regulation (Ryan & Deci, 2017). Each subtype plays a distinct role in influencing learners' engagement and performance, particularly in the context of mathematics learning. External regulation refers to motivation driven by external rewards or the avoidance of punishment. In mathematics learning, learners may engage in tasks primarily to receive grades or praise from teachers and parents, rather than for personal satisfaction or interest in the subject matter (Hsu et al., 2019). This form of motivation can lead to compliance but often lacks depth, as learners may not internalize the knowledge or skills being taught. Conversely, introjected regulation is a more internalized form of motivation, where learners are driven by internal pressures, such as the desire to avoid feelings of guilt or shame or to attain self-approval (Howard et al., 2021). For example, learners might push themselves to study mathematics to avoid disappointing their parents or to maintain a positive self-image, which can lead to a temporary boost in performance but may not foster a genuine interest in mathematics.

In contrast, identified regulation is characterized by a recognition of the personal value of a behavior, where learners engage in mathematics because they see its relevance to their goals or future aspirations (Howard et al., 2017). This type of motivation is more autonomous and can lead to sustained engagement and deeper learning, as learners connect mathematical concepts to their own lives and interests. For instance, a learner who understands how mathematics skills can aid in desired career may be more motivated to excel in the subject (Chiu, 2022).

Integrated regulation represents the highest level of extrinsic motivation, where behaviors are fully assimilated into the individual's sense of self and identity. In this case, learners not only recognize the value of mathematics but also integrate it into their self-concept, seeing themselves as capable mathematicians. This view can lead to a profound commitment to learning and a proactive approach to overcoming challenges in mathematics.

The current study highlights how these different forms of motivation manifest among learners in rural contexts, where learners often demonstrate a blend of identified and integrated regulation. They actively engage with mathematical content, not only to meet external expectations but also to fulfill personal goals and aspirations. This behavior reflects a sophisticated understanding of their learning processes, as they take ownership of their education and recognize the interconnectedness of mathematical concepts. The findings suggest that fostering an environment that supports autonomy and personal relevance in mathematics learning can enhance learners' motivation and lead to better educational outcomes. The four regulations play different roles in mathematics learning, and learners use them differently, depending on various factors.

Method

This study used a qualitative descriptive approach within a case study research design to explore and understand grade 10 learners' mathematics learning experiences and motivations in rural Acornhoek, Mpumalanga Province, South Africa. According to Merriam (1998), "reality is not an objective entity; rather, there are multiple interpretations of reality," acknowledging the "embeddedness of social truths" in case study research design (p. 22). This approach involved capturing the diverse perspectives of learners regarding their learning experiences and motivations for learning mathematics. The multiple case study approach allowed for an in-depth examination of how different forms of motivation, as outlined by SDT, influence learners' engagement and problem-solving strategies in mathematics, enabling the researchers to capture the nuanced experiences of learners as they navigated their learning environments. Employing this methodology, we delved into the nuanced perceptions of learners' lived experiences. The qualitative descriptive design was appropriate for this study as it recognizes the subjective experiences of the learners regarding their mathematics learning within rural schools. We listened carefully to the learners' word choices while they talked about their mathematics learning experiences. For reflective first-hand information, Wilkie and Sullivan (2018) note the value of interacting and listening to learners' views, thoughts, feelings, and experiences in learning mathematics.

Study Context

Acornhoek, in the central Bushbuckridge area of Mpumalanga Province, South Africa, exemplifies the complexities of defining rurality within the country. Approximately 447 km from Johannesburg, the remoteness of Acornhoek is highlighted by the logistical challenges we faced as researchers, including the absence of a dedicated office for the district manager, who convened meetings in a hall, reflecting the limited infrastructure typical of rural settings in the South African context. The spatial arrangement of educational institutions, with schools situated about 6 km from the district office and approximately 2 km apart, emphasizes the rural nature of the community, where resources are often scarce. The classification of Acornhoek as deeply rural or semirural is subjective, with residents' perceptions influenced by their proximity to amenities such as shopping centers and healthcare facilities. The dominant languages, Xitsonga and Sepedi, along with socioeconomic conditions, contribute to a nuanced understanding of rurality in Acornhoek, which is formally classified as rural by Statistics South Africa but reflects a more complex reality shaped by local experiences. The classification of Acornhoek as either rural or semirural presents a challenge due to differing perspectives. While Statistics South Africa (Stats SA, 2001) categorizes it as rural, rural communities have varying views, emphasizing the inadequacy of universal frameworks in capturing local nuances.

Learners in the study also expressed diverse opinions, with some perceiving the area as semirural or rural, based on factors such as access to amenities and residents' livelihoods. The dominance of farm work, poor infrastructure, and limited government services influenced the rural classification, aligning with the notion that residents' occupations can define a region's rural status. The learners highlighted the region's rural characteristics, citing dilapidated schools and inadequate facilities that hinder their access to high-quality education. This example highlights the importance of considering local perceptions alongside formal classifications to capture the lived experiences of rural communities. This discussion does not overlook the general guidance of government policy; rather, it considers the views of the participants.

Participants in the Study

The study purposively selected 12 learners from two secondary schools who could engage with the research questions and reflect on their mathematics learning experiences. We used the mathematics first-semester results to select the participants. In each school, we selected two learners above average (60% and above), two average (50%), and two below average (30%), resulting in six learners per school and a total of 12 for the study. It was important to include learners with varying performance levels and different learning experiences. We used pseudonyms to protect the learners' identities and labeled the schools as Bash and Dashboard Secondary Schools. The schools were selected conveniently based on partnerships with the Wits School of Education Rural Programme for preservice teaching practical.

Data Collection Methods

We used individual, face-to-face, semi-structured interviews to gain insights into learners' mathematics learning experiences. The format allowed for open conversations and identification of what motivates them to learn. We concur with Creswell (2003) that semi-structured interviews "enable research participants, including a researcher, to discuss their interpretations of the world in which they live, and to express how they regard situations from their own point of view" (p. 18). Of the 12 interviews, nine were conducted in classrooms after school, and for learners who could not stay after school due to the distance to their homes, three interviews were conducted on Saturday after study sessions. In all cases, interview settings were arranged to ensure no disturbances. Each interview lasted approximately 45–60 minutes, as it was important for learners to take their time to think and reflect on their learning experiences. We audio-recorded all interviews with the permission of the parents and learners (as they were considered minors), and parents observed the interviews. The recordings allowed us to listen carefully to and reflect on learners' responses.

We video-recorded unstructured classroom time to observe learners' engagement during mathematics lessons. We conducted two classroom observations per school and recorded what participants were doing and saying during the lessons, rather than relying solely on their verbal descriptions of classroom practices during the interviews. We adopted a non-participant observation approach, as we did not want to interfere with the lessons and learning process. We obtained consent from the principals, parents, and teachers to use video cameras in the classrooms and blurred the faces of learners and teachers when they appeared to protect their identities.

Data Analysis Technique

Data analysis was guided by the principles of SDT, focusing on the varying degrees of autonomy in learners' motivations, including external regulation, introjected regulation, identified regulation, and integrated regulation. This analytical lens facilitated a deeper understanding of how learners' motivations impacted their learning behaviors and outcomes, revealing the interplay between intrinsic motivation and self-determined learning processes in mathematics within a rural context. In this study, we employed Fairclough's (1993) three dimensions of analysis—description, interpretation, and explanation—while integrating the principles of SDT to enhance our understanding of learners' experiences in mathematics.

The description phase involved a detailed textual analysis that segmented and examined learners' spoken and written accounts of their mathematics learning, allowing us to identify the language they used to express their intrinsic motivations and challenges (Fairclough, 1993). This approach aligns with SDT's focus on intrinsic motivation, as the learners' word choices reflect their personal engagement and the value they place on their learning experiences.

The interpretation phase focused on how we, as researchers, processed and transformed these texts to uncover the meanings embedded in learners' narratives about their mathematics learning (Riasati & Rahimi, 2011). Janks (2010) states that "signifiers … make up the text, the specific linguistic selections and their juxtapositions, their sequencing, and layout" (p. 1). This analysis was informed by SDT, particularly in understanding how learners' motivations—ranging from external regulation to identified and integrated regulation—shaped their engagement with mathematics. By examining the factors that motivate learners, we discerned patterns of autonomy and agency in their learning processes.

The explanation phase involved a social analysis that considered the broader sociocultural context that influenced learners' experiences. This phase included examination of learners' linguistic choices, which reflect their intentions and thoughts shaped by their sociohistorical and political conditions (Riasati & Rahimi, 2011). By linking these dimensions of analysis to SDT, we provide a comprehensive understanding of how intrinsic motivation and learners' sense of autonomy contribute to their engagement and success in mathematics learning.

Since language is a social and cultural instrument, our sense of reality is socially and culturally constructed (Fulcher, 2010), which is a reason we quote learners' responses directly. The intention with this analysis was not to provide definite answers, but to expand understandings; realize learners' own shortcomings; and make their unacknowledged motivations, as well as those of others, known (Fairclough, 1993).

Results and Discussion

The findings from rural Acornhoek reveal a distinct approach to mathematics learning that contrasts with the experiences of learners in urban areas of South Africa. The information provided by the participants in this study highlights the importance of constant practice and the role of teachers in facilitating meaningful mathematics learning experiences. In this section, we discuss three themes: constant practice and teachers' role in the mathematics learning experience, doing it on my own and initiating the mathematics learning process, and peer collaborative learning.

In this study, learners emphasized the importance of self-initiated practice and reflection on classroom content, as illustrated by their commitment to revisiting and practicing mathematical concepts at home to overcome their abject poverty. In contrast, urban learners often benefit from more immediate access to resources, technology, and support systems that can facilitate their learning, potentially leading to a reliance on these external aids rather than developing intrinsic motivation and self-directed learning strategies. While the literature reviewed earlier does not specifically address urban learners' reliance on external aids, it is generally acknowledged in educational literature that access to resources can influence learning outcomes (Mbhiza, 2024). Furthermore, while rural learners exhibit a collaborative spirit through peer support and group study, urban learners may experience a more competitive educational environment, which can influence their motivation and engagement differently (Nkambule, 2017). This divergence highlights the need for educational strategies that are sensitive to the contextual realities of both rural and urban learners, ensuring that all learners can cultivate effective learning habits and achieve their mathematical potential.

Constant Practice and Teachers' Role in Mathematics Learning Experience

Participants' mathematics learning experiences underscore a strong link between dedicating time to consistent practice of content taught in class and reinforcing their understanding. For instance, Tsan'wisi from Bash Secondary explained,

> When I go home, I have to open the book and practice the numbers we have learned in the classroom. This helps me to revisit the content the teacher covered and ensure I understand the way she solved the problems.

This response highlights learners' recognition of the importance of revisiting and practicing mathematical concepts at home, which aligns with the principles of SDT that emphasize the role of autonomy in fostering intrinsic motivation (Mbhiza, 2024).

Similarly, Sunshine from Dashboard Secondary stated, "I will do well if I practice maths every day…. I won't forget anything that we learn from our teacher. It is a tough subject, so it's up to you to grasp it; follow your teacher." This comment reflects an understanding that personal effort and initiative are crucial for success in mathematics and illustrates the interplay between intrinsic motivation and self-regulated learning. A comment by Timane, a Bash Secondary student, further emphasizes learners' acknowledgement of their efforts and the mental effort required to grasp mathematical concepts:

> Maths is not easy if you don't give it time and practice all the time. I am not gifted; I work hard every day…, at least for 50% or so, not below.… It's not easy, but I manage for now.

These responses indicate a process of reflection and reconstruction in which learners integrate new ideas from their teachers with their existing knowledge. This process aligns with Howard et al. (2017), who suggest that learning involves bringing together and working on knowledge, fostering personal value and positive learning attitudes. While it is challenging to categorize the learners' approaches as either sophisticated or superficial learning strategies, their experiences illustrate that mathematics learning necessitates initiative, attentiveness, and mental effort, as evidenced by their active engagement during lessons (Chiu, 2022). Moreover, the learners' experiences reflect a multidimensional construct of motivation, in which the purpose of learning is not solely about achieving positive results but also about feeling in control of their learning goals (Moodley & Ross, 2015). The acknowledgment of their abilities signifies an internal drive that leads to self-regulated learning, contributes to positive performance, and recognizes the external rewards achieved through their intrinsic motivation. This process represents identified regulation, in which learners engage in behaviors based on perceived personal meaning and enjoyment derived from dedicated time and effort (Ryan & Deci, 2020).

Lukhele et al. (1999) assert, "Learning mathematics is not a matter of finding out what some other people want you to do under certain circumstances, it is a matter of personally constructing the knowledge you need to solve problems" (pp. 30–31). While they argue that learning mathematics is about personally constructing knowledge, the findings of this study reveal that for these participants, learning mathematics is a blend of understanding teacher expectations and actively participating in their own learning process. This approach promotes deeper processing and understanding, illustrating that mathematics learning experiences are not linear but rather a complex and multidimensional construct. The learners' responses highlight the importance of fostering an environment that supports autonomy, competence, and relatedness, as outlined in SDT, to enhance their motivation and engagement in mathematics learning.

Doing it on My Own: Initiating Mathematics Learning Process

This theme emphasizes the importance of learners taking ownership of their mathematics learning by engaging with new topics, guided by previous lessons, before the teacher introduces them in class. Participants demonstrated an understanding that effective learning involves integrating new information with existing knowledge, grappling with mathematical concepts, and establishing relationships between different problem-solving strategies. For instance, Brilliant from Bash Secondary stated, "I am ahead of my teacher. I always start new topics before the teacher; it's easy to see what's next, and I don't think I need to wait for a teacher." This proactive approach illustrates the autonomy that learners exercise in their education, a key component of SDT, which posits that autonomy is crucial for fostering intrinsic motivation (Mbhiza, 2024). James from Dashboard Secondary echoed this sentiment, saying, "When I get home, I practice the topic and then find the solution; from there, I go to another topic and don't wait for the teacher." His response highlights the initiative learners take in continuing their education outside the classroom, reinforcing the idea that mathematics learning is not solely dependent on teacher-led instruction. Similarly, Tiny from Dashboard Secondary explained, "It's all about practicing; mathematics is hard, but I always try and do it myself.… The teacher will catch up with me." These statements reflect a strong sense of agency and self-regulation, as these learners take control of their learning processes, aligning with Kosko's (2015) assertion that a personal sense of control is vital in SDT as it initiates self-directed activities.

Learners' enthusiasm for their work empowered them to ask questions and deepen their understanding through interactions with their teachers. Their responses illustrate a commitment to active engagement in the learning process, which is essential for developing a robust mathematical identity. As noted by Fairclough (1993), learners' word choices reflect their intentions and thoughts, consciously or unconsciously shaped by their sociohistorical context. This practice is evident in the way these learners articulate their learning experiences, indicating a reflective process where they identify knowledge gaps that can be clarified during lessons. Moreover, these learners' active participation in class, as they ask and respond to questions, exemplifies the interplay between autonomy and competence, which are fundamental components of SDT (Moodley & Ross, 2015). The learners' statements suggest that their motivation is not merely about external validation but also about internal satisfaction and pride in their achievements, which aligns with the concept of introjected regulation, in which learners seek to maintain self-approval and avoid feelings of guilt or shame (Neves & Du Toit, 2013).

We agree with Ayele and Dadi (2016) that the learners' levels of engagement in mathematics, characterized by active involvement and commitment, play a crucial role in fostering deep understanding. Participants' responses and observed actions in class exemplify introjected regulation, which represents internal dynamics related to self-esteem and pride-seeking, as the goal is to gain and maintain approval from oneself and others, avoiding guilt and shame (Hsu et al., 2019).

Despite the challenges these learners face, they demonstrate a willingness to engage with new concepts, which requires sophisticated mental effort and cognitive engagement (Mills et al., 2009). Bedenlier et al. (2020) assert that autonomy allows learners to choose their learning goals, fostering higher-order thinking as they synthesize and interpret mathematical concepts. Our findings indicate that learners can recognize the interconnectedness of mathematical topics, as they practice consistently and understand how concepts fit together in a cohesive system (Chiu, 2022). This recognition suggests that these learners employ sophisticated learning strategies, enhancing their mathematical knowledge and self-confidence. Their experiences illustrate that mathematics learning is a multidimensional construct in which autonomy, competence, and relatedness play crucial roles in shaping their educational journeys. By fostering an environment that supports these elements, teachers can enhance learner engagement and promote deeper learning in mathematics.

Peer Collaborative Learning

This theme presents findings on the advantages of collaborative learning. It was important for us to engage with the learners and allow them to speak for and about themselves, revealing the subjective meanings they attach to their mathematics learning experiences. SDT considers the environmental conditions in which learners act, as their learning experiences are influenced by how the learning environment satisfies their feelings of relatedness. The concept of relatedness refers to the degree to which an individual feels a sense of belonging to or connection with the environment, and it is a strong predictor of intrinsic motivation (Gibbons, 2014). In this study, cooperative learning was vital for the learners because they supported each other in learning, solving, and understanding mathematics problems by leveraging each other's strengths and addressing knowledge gaps. These participant responses illustrate this point.

> We help each other and rely on each other's knowledge for specific sections.… Sometimes you don't understand everything in maths. We form a group and get help from other learners so that we can all understand. (Sunshine, Dashboard Secondary)

> If you can do mathematics, we help each other so that we achieve together. We have started a peer group and meet after school and Saturday mornings and do maths together.... It's a difficult subject, but friends make it better. (James, Bash Secondary)

> Mathematics is a challenge. We don't fail because we are stupid, we don't know what those terms mean.… Friends help to explain using our language. I always look forward to Saturdays for discussions…. I leave understanding most things. I am not performing well, but I will continue to work hard. (Dave, Bash Secondary)

These comments illustrate that learners have realized the importance of collaborative knowledge construction for better understanding and new meanings. Group work transformed and enhanced learners' mathematics knowledge gaps and understanding. While learners acknowledged that mathematics can be difficult, they also recognized that friends could help with achieving externally controlled goals (Hsu et al., 2019). The learners' experiences exemplify highly self-determined integrated regulation—as individuals, they assimilate the enactment of a behavior into their sense of self, making the behavior a fully congruent element of their identity (Howard et al., 2017).

The learners' actions support Moletsane's (2012) argument to move beyond deficit paradigms about rural areas and adopt strength-based epistemologies that recognize that individuals and groups possess strengths, skills, knowledge, and resources that can be used for development that supports social change. Although Shahnaz and Gandana (2020) identify language limitations as one of the reasons for STEM challenges in rural schools, the learners' experiences demonstrated that using their mother tongue to explain some of the difficult mathematics concepts assists learners with understanding.

The findings show that learners' mathematics learning experiences were driven by individuals' personal values and meanings, or identified regulation, due to their determination to learn for deep understanding and achieve pride and external goals. The learners' participation in class during mathematics lessons was congruent with their self-motivation, as they took the initiative to prepare and practice before the lessons for active participation and asked questions for clarity and confirmation, and to enhance their understanding. Thus, these learners were intrinsically motivated and engaged in academic tasks because they enjoyed them (Mueller et al., 2012), and they collaboratively learned mathematics as one of the important strategies to share different ideas, solve mathematics problems, and accomplish a common goal (Lahann & Lambdin, 2020).

Although some learners exhibited elements of integrated regulation by assimilating the enactment of behavior to maintain their mathematics identity as part of the STEM status, they were agentic because, irrespective of difficulties, they took initiatives that constructively contributed to the learning processes. Learners in this study demonstrated resilience and determination, indicating that rurality does not always constitute a form of disadvantage and backwardness (Leibowitz, 2017); it should always be appreciated for its own sake (Soudien et al., 2019).

Conclusion

We argued that, although rural education has received little attention from researchers, untapped knowledge could contribute to education policy and initial teacher education. Participants recognized the important role that teachers play in introducing mathematical concepts and helping learners develop a coherent mathematics narrative, which represents different mathematical learning experiences. All participants acknowledged the significance of taking initiative and practicing mathematics consistently after school for meaningful learning. The findings suggest that participants had a general sense of satisfaction gained from solving mathematical problems and motivated by self-initiated mathematics learning, which addresses self-perceived competence.

Participants displayed a complex, multidimensional construct of behavioral, agentic, and emotional engagement, influenced by the roles of teachers, peers, and learning activities. Participants also challenged themselves intellectually by engaging with the teacher's work and by independently recognizing the interrelatedness of concepts and topics. They further realized that prior learning is important because it helps to identify knowledge gaps and formulate questions to ask during lessons. While all participants demonstrated agentic engagement with mathematics learning, we noted a link with introjected regulations related to avoiding shame and maintaining pride. Thus, agentic, behavioral, and emotional engagement were dominant in the learners' mathematics experiences, which is unsurprising, as they all recognized the importance of constant practice to understand mathematics. Cognitive engagement differed between the first and second themes, with the former appearing to use superficial learning strategies compared to the latter's more sophisticated strategies. Additionally, the identified and integrated regulations were more prominent in the second theme, owing to the nature of their initiatives and learning experiences.

The implications of these findings suggest some key points. Teachers should focus on building learners' confidence in their mathematical abilities by providing constructive feedback and opportunities for mastery. This strategy can be achieved through differentiated teaching that meets learners at their current skill levels, thereby fostering a sense of competence that is crucial for intrinsic motivation. Promoting learning approaches tailored to individual needs could boost learner motivation and engagement in mathematics.

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Suggested Citation:

Mbhiza, H. W., & Nkambule, T. (2025). Understanding grade 10 learners' mathematics learning experiences in rural schools: Applying the self-determination theory. *The Rural Educator*, *46*(3), 29–42.