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Investigating Barriers to Effective Chemistry Teaching in Rural Areas: A Case Study Analysis

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Abstract. This study explored the barriers to effective chemistry teaching and learning through a qualitative case study of selected rural secondary schools. Chemistry, as a practical and conceptually demanding subject, requires adequate laboratory facilities, instructional resources, supportive socio-economic environments, and accessible school infrastructure to ensure meaningful learning. However, rural schools often experience contextual challenges that compromise the delivery of quality chemistry education. This study sought to examine how resource limitations, socio-economic factors, geographical isolation, and infrastructure challenges affect chemistry teaching and learning in the selected rural school context. A qualitative case study design was employed to obtain in-depth insights into the lived experiences of teachers and learners. The study involved a purposive sample of forty (40) participants, comprising ten (10) chemistry teachers and thirty (30) Grade 12 learners. Data were collected using semi-structured interview guides for both teachers and learners. The data were analysed using thematic analysis to identify recurring patterns, themes, and relationships related to the research objectives. The findings revealed that resource limitations constituted the most significant barrier to effective chemistry teaching. The absence of functional laboratories, inadequate chemicals and apparatus, and limited access to up-to-date textbooks resulted in reduced practical experimentation and an overreliance on teacher-centred instructional methods. Socio-economic challenges, including poverty, limited parental support, and learner involvement in household responsibilities, negatively affected attendance, concentration, and time allocated for homework and revision. Geographical isolation constrained teachers' access to professional development and delayed the supply of laboratory materials, while also limiting learners' exposure to academic enrichment opportunities. Infrastructure deficiencies, such as unreliable electricity and water supply, overcrowded classrooms, and poor laboratory conditions, further restricted the safe and effective implementation of practical chemistry lessons. The study concluded that these barriers operate cumulatively within the rural school context, significantly undermining learners' conceptual understanding, practical competence, motivation, and academic performance in chemistry. The case study highlights the urgent need for targeted policy interventions and resource allocation strategies aimed at strengthening rural science education. The study recommends increased investment in laboratory infrastructure, improved distribution of teaching materials, enhanced professional development programs for rural chemistry teachers, and community-based initiatives to address socio-economic constraints affecting learners. Addressing these barriers is critical to promoting equitable access to quality chemistry education in rural secondary schools.

keywords: Chemistry Education, Rural Areas, Education Barriers, Socio-economic Factors, STEM Education, Case Study, And Purpose Sampling

I. Introduction

1 introduction to the Study

Chemistry education plays a vital role in equipping students with scientific knowledge and skills necessary for understanding and engaging with the world around them. However, the effectiveness of teaching chemistry, particularly in rural areas, is often hindered by various barriers. These may include limited access to resources, geographical isolation, inadequate teacher training, and infrastructural challenges, which collectively contribute to disparities in educational outcomes. This study aims to identify and analyse the specific obstacles faced by chemistry teachers in rural settings, deriving insights that can inform policy and practice improvements.

2. background of the Study

Chemistry is a foundational science that underpins many fields, including medicine, engineering, environmental science and technology. It cultivates critical thinking, problem solving skills and a deep understanding of matter and chemical processes that are vital for both informed citizenship and professional success. In contemporary society, where STEM (Science, Technology, Engineering and Mathematics) fields are increasingly recognized for their role in driving economic development and innovation, the significance of robust chemistry education cannot be overstated.

Rural education presents a unique set of challenges that often result in disparities compared to urban and suburban counterparts. A primary barrier is the lack of adequate teaching resources and poor infrastructure. Studies have shown that insufficient laboratory equipment, outdated facilities, and a shortage of instructional materials significantly limit the ability of teachers to conduct essential practical work in science subjects like chemistry (Edomwonyo-Otu & Avaa, 2011). The absence of necessary resources can directly lead to decreased student motivation, interest, and attitude toward science (Adeniran, 2020). Furthermore, poor infrastructure, including inadequate safety measures, can compromise the overall quality of science teaching (Netschivhumbe & Mudau, 2021). Rural schools such as Mumbi Boarding and Mwanjawantu secondary schools typically operate under tight budgets that prioritise basic education needs, leaving insufficient funds for science laboratory equipment and technology. The geographical remoteness of these rural areas can impede student`s access to supplementary educational resources. Additionally, Limited public transportation options restrict student's ability to travel to workshop, science fairs, tutoring programs, or other enrichment opportunities that are more readily available in urban environments. This isolation often contributes to students feeling disconnected from scientific community and inhibits collaborative learning experiences. This case study focuses on the barriers to effective chemistry teaching in rural secondary schools.

3. Problem Statement

Despite the importance of chemistry education, rural Schools frequently experience significant barriers that impede effective teaching and create a pronounced disparity between educational opportunities in urban and rural contexts. These barriers may include inadequate resources, demographic isolation and socio-economic factors affecting student participation. Understanding these issues is vital for improving educational practices and outcomes.

4. Purpose of the Study

The primary aim of this research is to investigate the barriers to effective chemistry teaching in rural areas and to propose strategies for overcoming these obstacles to enhance student learning outcomes.

5. Objectives of the Study

- To identify and categorize the specific barriers that impact chemistry teaching in rural areas.
- To assess the impact of these barriers on both teacher and student performance in chemistry.

6. Research Questions

- What are the key barriers faced by chemistry teachers in rural areas?
- How do these barriers impact the teaching and learning processes in chemistry?

7. Significance

The study on barriers to effective chemistry teaching in rural areas holds considerable significance across multiple dimensions, including educational, policy-making, social, and academic perspectives. From an educational standpoint, the study contributes to improved teaching and learning by identifying specific challenges that hinder effective chemistry instruction. These insights can help educators develop better teaching strategies that are suited to rural contexts. In addition, the findings can inform curriculum development by guiding curriculum designers to create content, materials, and teaching approaches that address the unique conditions and limitations found in rural classrooms.

From a policy perspective, the study plays an important role in guiding decision-making processes. Educational policymakers can use the findings to design targeted interventions that address the real needs of rural schools and teachers. Furthermore, the study provides valuable information for resource allocation, ensuring that funding, teaching materials, and training opportunities are distributed more equitably and effectively to support under-resourced rural schools.

The study also has significant implications for community engagement. By highlighting the challenges faced in rural education, it encourages greater involvement from local communities, including parents and community-based organizations, in supporting chemistry education. Additionally, the dissemination of the study's findings can raise awareness about the difficulties encountered in rural schools, thereby mobilizing community support, advocacy, and resource contributions toward improving educational outcomes.

In terms of student outcomes, the study is crucial in promoting better engagement and academic performance among learners. By understanding the barriers to effective teaching, strategies can be developed to make chemistry more engaging and accessible, ultimately improving students' interest and achievement in the subject. Moreover, effective chemistry teaching contributes to the development of scientific literacy, which is essential for students' future academic pursuits and career opportunities in a science-driven world.

Academically, the study contributes to existing knowledge by filling gaps in research related to rural education, particularly in the field of science education. It provides a focused analysis of the challenges specific to chemistry teaching in rural settings. The findings can also serve as a foundation for future research, offering a framework that other researchers can build upon when investigating educational challenges in similar or different contexts.

The study further supports professional development among teachers. By identifying the specific barriers faced by chemistry educators in rural areas, it can inform the design of targeted teacher training programs that equip educators with the necessary skills and knowledge to overcome these challenges. In addition, the findings can encourage the establishment of mentorship opportunities, where experienced teachers support and guide those working in rural schools, thereby enhancing professional growth and teaching effectiveness.

In the long term, the study has the potential to contribute to sustainable educational practices. By addressing the root causes of ineffective chemistry teaching, it promotes solutions that can be maintained and adapted over time. Improved education in rural areas can also lead to the empowerment of communities, resulting in better employment opportunities, economic development, and an overall improvement in quality of life.

Finally, the study has broader implications for STEM education. Effective chemistry teaching can inspire interest in science, technology, engineering, and mathematics fields among rural students, helping to build a more diverse and inclusive pipeline of future professionals. It also promotes equity in education by emphasizing the need to address disparities faced by rural learners and ensuring that all students, regardless of their location, have access to quality education and equal opportunities to succeed.

8. Delimitation

This study was deliberately confined to examining the barriers to effective chemistry teaching in selected rural secondary schools in Zambia. The focus on rural schools was intentional, as the research sought to explore contextual challenges that are unique to geographically isolated and resource-constrained environments. Urban and Peri-urban schools were not included in the investigation, as their conditions differ significantly in terms of infrastructure, access to resources, geographical position and socio-economic dynamics. Therefore, the findings of this study are specifically applicable to rural educational settings and may not be generalized to urban contexts without caution.

The study concentrated exclusively on the subject of chemistry at the senior secondary school level (Grades 10–12). Chemistry was selected due to its strong practical component and reliance on laboratory facilities, equipment, and qualified teachers, which are often limited in rural areas. By narrowing the focus to chemistry, the study was able to provide a more in-depth analysis of subject-specific challenges rather than offering a broad but superficial examination of science education in general.

In terms of content scope, the research was limited to four key barriers: resource limitations, socio-economic factors, geographical isolation, and infrastructure challenges. While other factors such as language barriers, curriculum design, policy implementation, teacher motivation, and administrative leadership may also influence chemistry teaching effectiveness, these were not explored extensively unless they directly related to the four selected variables. This delimitation ensured that the study remained focused and manageable within the available timeframe and research capacity.

Methodologically, the study adopted a case study design involving selected participants, including chemistry teachers and learners. The sample size was limited to respondents from chosen schools and did not include all rural secondary schools in Zambia. Consequently, the findings reflect the experiences and perceptions of participants within the selected schools and are not statistically representative of all rural schools nationwide. The research also relied primarily on interviews for data collection and did not include experimental interventions or longitudinal tracking of academic performance trends.

Furthermore, the study did not assess government funding structures beyond their observable impact at the school level. The research also excluded private secondary schools and focused only on government institutions operating in rural settings. Financial constraints, time limitations, and accessibility challenges influenced these decisions.

9. limitation of the study

The research involved limited generalization because the study focussed on specific rural areas, which limited the applicability of findings to other rural contexts with different socio-economic or cultural dynamics. The study also involved a smaller sample size which could not capture the diversity of experiences, potentially leading to biases in understanding the broader issues.

Participant`s biasness affected the study as it involved social desirability as some participants provided responses they believed were expected or socially acceptable rather than expressing their true feelings or experiences. In addition, some participants who chose to engage had stronger opinions or experiences regarding chemistry education, which skewed findings.

Time constraints was also another factor, that translated to limited observation period. A short observation window could not adequately capture the full range of teaching practices and pedagogical challenges over an academic year.

The study also faced some limitation in ethical consideration, such as informed consent issues. Ensuring that all participants fully understand the study`s purpose and their rights was challenging, especially in communities with varying levels of education and literacy. Furthermore, maintaining the anonymity of participants was difficult in small rural communities where individuals know each other, potentially affecting their willingness to share candidly.

10. Operational Definition of Key Terms

- Chemistry Education: The field of study focused on teaching and learning chemistry, including curriculum development, instructional strategies, and assessment practices to foster understanding of chemical principles.
- Rural Areas: Regions characterized by low population density, often located outside urban centres. These areas may have limited access to educational resources and services.
- Educational Barriers: Challenges that impede effective teaching and learning, such as resource shortages, insufficient teacher training, and socio-economic disadvantages that affect student performance.
- Socioeconomic Factors: Social and economic conditions that influence individual and group behaviour, including income levels, education, occupation, and family background, which can affect educational attainment.
- STEM Education: An interdisciplinary approach to teaching science, technology, engineering, and mathematics, aiming to prepare students for careers in these critical fields.
- Case Study: A research method that involves an in-depth analysis of a specific instance or example, often used to explore complex issues and derive insights.
- Purposive sampling-this is also known as Judgemental or non-probability sampling.

11. Conclusion

In summary, the barriers to effective chemistry teaching in rural areas present significant challenges that require urgent attention. Limited resources, socioeconomic disadvantages, and geographic isolation collectively impede the quality of chemistry education available to students in these settings. This study aims to investigate these barriers through a case study approach, providing a detailed analysis that can inform policy and practice improvements. By addressing the specific needs and contextual factors of rural educators and students, this research seeks to contribute to the development of equitable educational opportunities in chemistry and enhance student outcomes in underserved communities. The subsequent chapters will delve deeper into the literature surrounding these issues, the methodology employed in the study, and the findings that emerge from this comprehensive analysis

II. Literature Review

1. Introduction

This chapter includes some research gap and related literature and studies done by the foreign and local researchers

2. Research Gap

While there has been substantial research on chemistry education in urban contexts, there is paucity of studies specifically focusing on rural areas. existing literature often overlooks the unique challenges faced by rural educators and students, leading to a gap in comprehensive understanding and targeted strategies. this study seeks to fill this gap by providing a focused analysis of barriers to effective chemistry teaching in the rural environments, thus contributing to the broader discourse on educational equity and quality.

This chapter reviewed existing literature on barriers to effective chemistry teaching in rural areas. The review was structured into three sections: global, African, and Zambian contexts. It centred on four major themes identified as barriers: resource limitations, socio-economic factors, geographical isolation, and infrastructure challenges.

Global Perspectives on Barriers to Rural Chemistry Teaching

Resource Limitations

Globally, educational researchers have extensively documented the lack of science teaching resources in rural schools. Chemistry, as a practical science, depends heavily on laboratories, equipment, and consumables. When these are unavailable, teachers are forced to rely on textbook and chalkboard explanations, limiting learners' experiential learning opportunities (International Journal of Educational Research Open, 2024). Resource inadequacy not only diminishes the quality of instruction but also demotivates teachers and learners alike.

Global studies consistently report that rural schools lack adequate resources required for effective chemistry teaching. Chemistry is a discipline that depends on laboratory experimentation to complement theory (National Academies of Sciences, Engineering, and Medicine, 2019). Without chemicals, apparatus, protective gear, and instructional models, teachers are forced to rely on lecture-based methods that may fail to develop deep conceptual understanding (Bamford & Osborne, 2018; Ogunleye & Ogunkola, 2018). In the United States, for instance, rural schools with limited lab access have significantly lower achievement in chemistry when compared with urban counterparts, where laboratories are functional and experiments are regularly integrated into instruction (National Academies of Sciences, Engineering, and Medicine, 2019).

Textbook inadequacy is another dimension of resource limitations. Studies in Europe and Asia highlight that rural learners often share a single textbook or have no textbook at all, undermining independent study and revision (Sharma & Bulunuz, 2019). In chemistry, where learners must engage with complex terminology and mathematical applications, this shortage leads to shallow learning and rote memorisation instead of meaningful understanding (Van Den Broek & Kim, 2021).

Globally, researchers argue that resource shortages cause teachers to default to teacher-centred methods that emphasise memorisation rather than investigation, resulting in learners who can recite definitions but cannot conduct experiments or solve real-world chemical problems (World Bank, 2020). As a result, rural students are less prepared for higher education in science disciplines and for careers demanding scientific literacy.

Socio-Economic Factors

Socio-economic disadvantages significantly affect learners' capabilities to engage with chemistry. In many rural contexts worldwide, poverty results in limited access to textbooks, study spaces, and parental support for learning (Mkuzo & Govender, 2024). Additionally, learners often assume household or income-earning responsibilities, reducing study time and school attendance. Such socio-economic constraints are linked to lower achievement in science subjects, including chemistry.

Socio-economic barriers profoundly influence learner participation and outcomes in rural chemistry classrooms. Poverty limits access to study materials, supportive guidance, and supplementary learning opportunities. In rural Latin America, for example, learners from low-income households often prioritise household labour over study time, leading to irregular school attendance and reduced engagement with chemistry content (UNESCO, 2021). Since chemistry builds cumulatively — where concepts in earlier modules support comprehension in later topics — irregular attendance disrupts learning continuity, leaving gaps that disadvantage rural learners.

Research in rural Asia has similarly shown that socio-economic status affects learners' attitudes toward chemistry. Students whose families struggle to meet basic needs often view science subjects as less relevant to their immediate concerns, resulting in disengagement and reduced motivation (Sharma & Bulunuz, 2019). Without encouragement or support at home, learners are less likely to seek help, participate in study groups, or pursue enrichment activities that reinforce classroom learning.

Globally, socio-economic disadvantage is linked to fewer opportunities for rural students to access private tutoring, laboratory excursions, or digital learning platforms, which many urban learners take for granted (World Bank, 2020). In chemistry, where conceptual difficulty is high, these missing supports significantly undermine rural learner attainment.

Geographical Isolation

Geographical isolation refers to the physical remoteness of schools from population centres, professional networks, and resource distribution hubs. Rural schools that are geographically isolated face challenges in accessing professional development for teachers, acquiring learning materials, and engaging learners in broader academic experiences (Mkuzo & Govender, 2024; Mumba & Ng'ambi, 2017). Teachers in isolated areas often miss out on workshops, curriculum training, and science education reforms because travel costs and distances hinder participation (Shambare & Jita, 2025).

Isolated schools also receive deliveries of laboratory chemicals and equipment less frequently. Poor roads and long distances from suppliers increase logistical costs and delays (Shikalepo, 2020). These barriers affect the timeliness and quality of resources available for chemistry instruction, leading to lessons based on outdated materials or improvised tools that do not faithfully represent scientific phenomena.

From a learner perspective, geographical isolation limits access to science fairs, regional competitions, and extracurricular enrichment programs that can spark interest and deepen understanding of chemistry (Van Den Broek & Kim, 2021). Without opportunities to see chemistry applied outside the classroom — such as in industry visits or university demonstrations — rural learners may view the subject as abstract and disconnected from real life, further dampening engagement. Rural schools worldwide are often situated in remote locations far from urban centres, universities, and major educational support structures. This geographical isolation restricts teachers' access to professional development workshops, collaborative networks, and science teaching resources (Shambare & Jita, 2025). It also limits learners' exposure to science enrichment activities such as competitions and STEM camps, which are often based in urban areas.

Infrastructure Challenges

Infrastructure encompasses not just laboratory rooms but also utilities (water, electricity), storage facilities, ventilation, and classroom space. Rural schools in many countries lack dedicated science laboratories, or the ones they have are not safe or functional (Mutiso & Chigonga, 2020; Teshome, 2021). In Africa and parts of rural Europe, classrooms are overcrowded and lack basic safety equipment, making practical chemistry instruction hazardous or impossible.

Without electricity, teachers cannot use digital simulations, microscopes with displays, or electronic teaching aids that support visualisation of chemical processes (Mkuzo & Govender, 2024). A lack of proper water supply inhibits common chemistry tasks such as solution preparation and apparatus cleaning, further restricting practical work. Overcrowded classrooms prevent effective grouping for experiments and limit teacher supervision during activities requiring careful observation (Mutiso & Chigonga, 2020).

Across global research, infrastructure deficits are consistently correlated with low achievement in chemistry. Schools with poor physical conditions not only struggle to deliver practical lessons but also exhibit lower learner motivation and higher dropout rates, particularly in science streams (Owoeye & Yara, 2019).

Infrastructure inadequacies — including lack of dedicated laboratory facilities, poor classroom conditions, and unreliable electricity or water — significantly impair the delivery of chemistry instruction. Without proper laboratory space, practical demonstrations essential for chemistry are seldom performed, leading to superficial learning (International Journal of Educational Research Open, 2024). In poorly ventilated or overcrowded classrooms, safety risks further constrain practical science teaching.

Summary of the Global Literature:

Global literature reveals that barriers often compound one another. Resource limitations are exacerbated by socio-economic constraints — when families cannot afford supplementary materials, the lack of school resources hits learners doubly hard. Geographical isolation limits access to additional support structures, while infrastructural challenges prevent even the basic implementation of practical chemistry curricula (UNESCO, 2021; World Bank, 2020). Together, these barriers contribute to inequitable science education outcomes between urban and rural contexts.

African Context

Resource Limitations

In many African countries, rural schools face severe shortages of laboratory apparatus, chemicals, textbooks, and teaching aids (Shikalepo, 2020). Without proper lab equipment, teachers cannot conduct experiments that are central to chemistry learning, which results in learners' weak conceptual understanding (Shambare & Jita, 2025). This scarcity makes chemistry one of the subjects with the lowest practical engagement in rural African schools.

Studies in South Africa and Nigeria highlight that chemical reagents, glassware, and safety gear are either absent or insufficient to support full syllabus coverage (Chika & Agbor, 2019; Makena & Muna, 2019). Teachers often improvise apparatus using locally available materials, but these lack precision and fail to elicit clear scientific results.

The shortage of textbooks and reference materials is also severe in rural Africa, where curricula are sometimes delivered without learners owning individual books or having access to digital content (Sharma & Bulunuz, 2019). Because chemistry involves a specialised vocabulary and mathematical concepts, the absence of personal study materials reduces comprehension and slows learner progress.

These resource deficits mean that chemistry instruction often remains at lower cognitive levels, emphasising memorisation rather than analysis and experimentation — a trend that undermines long-term science competence (Shambare & Jita, 2025).

Socio-Economic Factors

Poverty remains a pervasive challenge in rural Africa. Studies show that learners from low-income rural families lack basic learning materials and study space outside school, a situation that correlates with lower academic performance in science subjects (Shikalepo, 2020). Additionally, learners frequently miss school during peak agricultural seasons to assist with family labour, interrupting instructional continuity in subjects like chemistry.

Research in Kenya and Zimbabwe show that students engage in household agriculture and income generation at the expense of study time (Muriithi, 2022; Shikalepo, 20200. This reality impacts attendance and exam preparedness, especially for cumulative subjects like chemistry.

Moreover, parental education levels are frequently low, limiting academic support at home. Learners without informed encouragement or study guidance struggle to navigate chemistry`s abstract concepts, which require sustained practice and higher-order thinking (Nkombo & Mthembu, 2023).

Social-economic hardships also restricts access to paid tutoring or enrichment programs, widening the gap between rural learners and their urban peers who are more likely to afford such supports.

Geographical Isolation

Rural areas in Africa are often characterized by poor road networks and long distances from district centres. Teachers in these areas report limited opportunities for in-service training and professional networking due to transportation challenges and high travel costs (Shikalepo, 2020). The lack of connectivity also restricts access to educational innovations and support structures that could improve chemistry teaching.

Studies show that teachers in rural contexts rarely attend workshops or science professional developments activities due to travel distances and costs (Shikalepo, 2020; Shambare & Jita, 2025).

Similarly, rural learners often have restricted access to science competitions and academic events that could supplement classroom learning. Geographic isolation also affects supply chains for laboratory materials, creating unpredictable access to chemicals and consumables necessary for practical lessons.

Infrastructure Challenges

Infrastructure deficits in rural African schools remain widespread. Research from South Africa notes dilapidated classrooms, absence of laboratories, and insufficient utility services (Shambare & Jita, 2025). These conditions prevent effective delivery of practical science lessons, diminish learners' engagement, and undermine safety during laboratory activities.

Infrastructure deficiencies are pervasive in rural African schools. Research across multiple countries points to dilapidated buildings, overcrowded classrooms, inadequate utilities and absence of proper science laboratories (Mutiso & Chigonga, 2020; Teshome, 2021). These conditions constrain the implementation of chemistry curricula that mandate regular practical exercises.

For example, a lack of running water makes even basic experimental preparation difficult, while ventilation poses safety risks when handling reactive chemicals. The absence of electricity inhibits the use of digital learning supports and virtual simulations that can enrich theory when resources are limited.

Summary of African Literature:

African studies reinforce global findings while highlighting contextual specifics, such as the role of local economies and community education levels in shaping educational outcomes. The compounded effects of resource scarcity, socio-economic pressures, isolation, and poor infrastructure result in rural learners who underperform in chemistry compared with peers in better-resourced areas (UNESCO, 2021).

Barriers to Chemistry Teaching in Zambia

Resource Limitations

Although specific research on chemistry education in Zambia is limited, general studies on rural schools indicate that lack of textbooks, laboratory facilities, and teaching materials significantly hampers science instruction (Lembani, 2021). Without adequate instructional resources, rural chemistry teachers are compelled to prioritize theory over practice, which to learners appears abstract and difficult.

In Zambia, socio-economic hardship in rural communities directly influences school participation and learning behaviour. Many learners contribute to family labour, especially during planting or harvest seasons, resulting in absenteeism and reduced study time (Chama, 2025). Similarly, limited access to study resources at home constrains revision outside school.

These socio-economic constraints contribute to a learning environment where chemistry, with its abstract concepts and demanding cognitive requirements, becomes particularly difficult for rural learners.

Socio-Economic Factors

Rural Zambian learners often face socio-economic hardships that affect their academic engagement. Low parental income limits access to textbooks and stationery, while household labour responsibilities compete with study time (Dorica, 2025). These factors contribute to low learner participation and underperformance in science subjects, including chemistry.

In Zambia, socio-economic hardship in rural communities directly influences school participation and learning behaviour. Many learners contribute to family labour, especially during planting or harvest seasons, resulting in absenteeism and reduced study time (Chama, 2025). Similarly, limited access to study resources at home constrains revision outside school.

These socio-economic constraints contribute to a learning environment where chemistry, with its abstract concepts and demanding cognitive requirements, becomes particularly difficult for rural learners.

Geographical Isolation

Geographical remoteness is a persistent challenge in Zambia's rural provinces. Schools far from district centres struggle to connect with training programmes and resource distribution systems. Teachers in these areas often miss professional development workshops, leaving them with limited exposure to new instructional methods (Chama, 2025). Supply delays for chemistry materials are common, affecting lesson planning and execution.

Learners similarly miss district-level academic events and science competitions, reinforcing feelings of exclusion from broader educational opportunities.

Infrastructure Challenges

Infrastructure issues in rural Zambian schools — such as lack of laboratories, overcrowded classrooms, and unstable utility services — hinder effective chemistry teaching (Lembani, 2021). The absence of dedicated lab space and safety equipment restricts practical activities, which are critical for learners' understanding and interest in chemistry.

Summary of Zambian Literature: In Zambia, rural schools share similar barriers identified globally and regionally. Resource shortages, socio-economic constraints, geographical remoteness, and infrastructure deficits together create environments that are not conducive to effective chemistry education.

Impact of Identified Barriers on Chemistry Education (From Literature)

Literature across global, African, and Zambian contexts does not only identify barriers in rural schools, but also explains how these barriers directly affect the teaching and learning of chemistry, a subject that heavily depends on practical work, experimentation, and conceptual understanding.

Impact of Resource Limitations on Chemistry Education

Resource limitations are widely cited in the literature as the most critical barrier to effective chemistry teaching in rural schools. Chemistry is a practical and experimental science that depends heavily on the availability of laboratories, chemicals, apparatus, models, charts, and textbooks to make learning meaningful. When these resources are inadequate or absent, the entire nature of chemistry teaching changes from experimental learning to theoretical storytelling.

The shift from practical to theoretical teaching was one of the major challenges affecting the effective teaching of chemistry in rural schools. Chemistry concepts such as reactions, gas production, titration, electrolysis, and rates of reaction are best understood through observation and experimentation. However, in resource-limited environments where laboratories and chemicals are unavailable, teachers are often forced to rely on verbal explanations or draw diagrams on the board. As a result, learners tend to memorize chemical reactions without actually observing them, making learning abstract and difficult to grasp. Consequently, many learners perceive chemistry as complicated and confusing.

Another significant challenge is the poor development of practical and investigative skills. Essential competencies in chemistry, such as measuring volumes, handling apparatus, observing colour changes, and accurately recording results, require hands-on experience. In the absence of experimental materials, learners are unable to develop these skills effectively. This leads to a lack of practical laboratory competence, poor performance in practical examinations, and reduced confidence among learners when conducting experiments.

The lack of practical activities also contributes to reduced learner interest and motivation. Experiments make chemistry more engaging by allowing learners to observe reactions, colour changes, and gas formation, which stimulate curiosity and excitement. Without such experiences, lessons become monotonous and purely theoretical. As a result, learners often lose interest in the subject, develop negative attitudes toward chemistry, and show reduced participation during lessons.

In addition, there is an overdependence on teacher explanations, especially in situations where textbooks and other learning materials are limited. Learners rely heavily on the teacher as their primary source of information, which limits independent learning. This makes it difficult for learners, particularly slow learners, to revisit and understand concepts at their own pace. Consequently, the learning process becomes teacher-centred rather than learner-centred.

The inability to relate chemistry to real-life situations is another major issue. Chemistry plays a significant role in explaining everyday phenomena such as rusting, cooking, fermentation, and the use of cleaning agents. However, without demonstrations and practical experiences, learners struggle to connect theoretical knowledge to real-life applications. This makes chemistry appear irrelevant to their daily lives and results in poor conceptual understanding of various topics.

Furthermore, the lack of practical exposure negatively affects learners' performance in chemistry examinations. National examinations often include practical components and application-based questions. Learners from resource-limited schools are therefore at a disadvantage because they have little or no experience performing the required experiments. This leads to low pass rates and generally poorer grades compared to learners from well-resourced schools.

Finally, the situation also affects teachers, leading to frustration and reduced teaching effectiveness. Teachers who are trained to deliver practical-based lessons become demotivated when they are unable to conduct experiments due to a lack of resources. This results in reduced morale, limited innovation in lesson delivery, and increased reliance on outdated, teacher-centred methods of instruction.

Impact of Socio-Economic Factors on Chemistry Education in Rural Areas

Socio-economic conditions of learners and communities play a significant role in determining educational outcomes, particularly in subjects like chemistry that require sustained cognitive engagement, access to learning resources, and experiential learning opportunities. In rural settings, where poverty and limited economic opportunities are more prevalent than in urban areas, the socio-economic realities of families, schools, and communities directly influence both teaching and learning processes in chemistry.

Limited access to learning materials is a major barrier to effective chemistry learning in rural areas. Chemistry is a resource-intensive subject that requires textbooks, notebooks, reference materials, and supplementary guides. However, learners from low-income rural families often cannot afford these essential materials which restrict their ability to study effectively both in and out of school. As a result, students miss opportunities for revision, practice, and reinforcement of concepts learned in class, leading to gaps in understanding and mastery of chemistry content. At the same time, teachers are forced to spend more time covering content that learners cannot independently access, placing additional pressure on limited classroom time.

Another challenge is the burden of household economic responsibilities, which contributes to time poverty among learners. In many rural settings, students are expected to engage in activities such as farming, fetching water, or caring for younger siblings. These responsibilities reduce the time available for homework, revision, and even regular school attendance. Consequently, learners often experience irregular attendance and lower engagement in class. Since chemistry concepts build progressively, missing lessons disrupts continuity, making it difficult for learners to understand complex topics such as stoichiometry, chemical bonding, and reaction kinetics.

Inadequate home study environments further compound the problem. Many rural households lack basic facilities such as electricity, quiet study spaces, and access to learning technologies like radios or internet-enabled devices. Without proper conditions for studying, learners struggle to concentrate, revise, and fully understand chemistry concepts, which often require critical thinking, problem-solving, and consistent practice. This situation also creates inequality, as learners from more privileged backgrounds are able to supplement their learning through tutoring and digital resources, while rural learners remain disadvantaged.

Parental education and support also play a significant role in learners' academic success. In many rural areas, parents may have limited formal education, which reduces their ability to assist with schoolwork, particularly in technical subjects like chemistry. The lack of academic support at home can negatively affect learners' motivation and interest in the subject. Additionally, families with limited financial resources are more likely to prioritize basic needs such as food and clothing over educational materials, which further limit learners' preparedness and engagement in school.

Financial barriers also prevent learners from accessing extra learning opportunities such as science camps, competitions, tutoring programs, and enrichment activities. These opportunities often require transport costs and participation fees that are beyond the reach of many rural families. As a result, learners miss out on valuable experiences that could deepen their understanding of chemistry and stimulate interest in the subject. This lack of exposure also affects learners' confidence, as participation in such programs helps build a positive identity as a science learner.

Overall, these socio-economic challenges have a cumulative effect on learners' academic achievement. Limited resources, irregular attendance, inadequate study environments, and low motivation collectively contribute to poor performance in chemistry. Research indicates that learners from low socio-economic backgrounds in rural areas tend to perform less well in science subjects due to these systemic disadvantages. Furthermore, poor performance at lower levels reduces the likelihood of learners pursuing chemistry or other science-related subjects at higher levels, ultimately limiting their future educational and career opportunities in science fields.

Impact of Geographical Isolation on Chemistry Education in Rural Area

Geographical isolation refers to the physical distance and remoteness of rural schools from urban centres, educational hubs, and support services. In many developing contexts, rural schools are located far from district offices, teacher training institutions, resource centres, and markets. This physical separation is not merely a matter of distance — it creates a network of challenges that directly affect the quality of instruction and learning in subjects requiring specialized resources and engagement, such as chemistry.

Geographical isolation has a profound impact on the quality of chemistry education in rural schools, particularly through limited access to professional development and support for teachers. In many remote areas, teachers face significant challenges in attending workshops, refresher courses, laboratory training sessions, and science education conferences. Transportation difficulties, high travel costs, and the absence of substitute teachers make it difficult for them to leave their schools for professional training. As noted by Shikalepo (2020), these constraints prevent rural teachers from upgrading their knowledge and skills. Similarly, Shambare and Jita (2025) highlight that distance from urban centres limits teachers' exposure to modern teaching approaches, such as inquiry-based learning and the use of virtual laboratories. As a result, teachers often remain less informed about current chemistry teaching strategies, rely heavily on traditional lecture methods, and are less able to implement innovative, student-centred approaches that are essential for effectively teaching complex scientific concepts.

In addition to professional development challenges, geographical isolation creates significant barriers to accessing educational resources and laboratory materials. Remote schools often experience delays or complete lack of delivery of essential items such as chemicals, laboratory apparatus, safety equipment, and instructional kits. Poor road networks, seasonal weather conditions, and high transportation costs further complicate the situation. According to Shikalepo (2020), some rural schools are deprioritized in the distribution of resources due to the logistical difficulties involved. Consequently, teachers are unable to plan or conduct practical experiments consistently, and schools lack the basic materials needed for hands-on science activities. This deprives learners of opportunities to engage in experimental work, which is critical for developing a deeper understanding of chemistry concepts.

Geographical isolation also limits learners' exposure to enrichment activities that enhance their understanding and interest in chemistry. Activities such as science fairs, academic competitions, educational field trips, workshops, and collaborative projects are often organized in urban or central locations, making them inaccessible to many rural learners. Financial constraints and lack of transportation further restrict participation. As observed by Shambare and Jita (2025), this limited exposure reduces learners' motivation and interest in pursuing chemistry. Without opportunities to interact with peers, showcase their abilities, or experience science beyond the classroom, learners miss out on valuable academic and social engagement. This, in turn, weakens their ability to relate chemistry to real-world applications and diminishes the overall relevance of the subject.

Another critical effect of geographical isolation is the lack of access to academic support networks. Teachers in remote areas often have limited opportunities to participate in cluster meetings, subject panels, peer mentoring programs, and professional collaborations. This isolation reduces the exchange of ideas, teaching strategies, and learning materials among educators. As a result, teachers may feel professionally unsupported and isolated, which can negatively affect their motivation and effectiveness. Without guidance from subject specialists or collaboration with colleagues, teachers may struggle with curriculum interpretation and delivery. This leads to a static form of instruction that lacks innovation and continuous improvement, ultimately affecting the quality of chemistry education provided to learners.

Furthermore, geographical isolation is closely linked to challenges in technology access and digital connectivity. Although modern technology has the potential to bridge educational gaps through online training, virtual laboratories, and digital resources, many rural schools lack reliable internet connectivity and adequate digital infrastructure. Mkuzo and Govender (2024) identify this digital divide as a major issue, with rural schools lagging significantly behind their urban counterparts in access to information and communication technologies. Without stable internet access, teachers cannot participate in online professional development programs, webinars, or virtual learning communities. Similarly, learners are unable to benefit from interactive simulations, virtual experiments, and digital textbooks that could enhance their understanding of chemistry. As a result, valuable digital tools that could make chemistry more engaging and accessible remain largely underutilized.

Overall, the combined effects of geographical isolation significantly hinder the effectiveness of chemistry education in rural settings. It limits teacher professional growth and reduces opportunities for adopting innovative teaching methods. It also restricts the availability and timely delivery of laboratory materials, making practical instruction difficult. In addition, it reduces learners' access to enrichment activities and collaborative learning experiences, while also constraining academic support networks for teachers. The lack of reliable digital connectivity further widens the educational gap between rural and urban schools. Together, these challenges create a learning environment that is less interactive, less resource-supported, and less conducive to strong academic performance, ultimately affecting learners' outcomes and their future opportunities in science-related fields.

Impact of Infrastructure Challenges on Chemistry Education

Infrastructure plays a critical role in supporting effective teaching and learning, particularly in subjects like chemistry that rely heavily on practical work and experimentation. It includes essential physical facilities and services such as classrooms, laboratories, electricity, water supply, storage rooms, and sanitation. In many rural schools, these infrastructural components are either inadequate or completely lacking, which significantly affects the delivery of chemistry education. Because chemistry requires safe, well-equipped environments for demonstrations and experiments, poor infrastructure directly limits both teaching effectiveness and learner understanding.

One of the most significant challenges is the absence or poor condition of laboratories. A functional laboratory is central to the teaching of chemistry, as it provides a space where learners can observe and conduct experiments. However, many rural schools either do not have laboratories or have poorly maintained and under-equipped rooms designated as laboratories. According to Lembani (2021), such facilities are often unsafe and unsuitable for practical work. As a result, teachers are unable to conduct experiments that demonstrate chemical reactions, forcing them to rely on chalkboard explanations instead. This deprives learners of the opportunity to develop essential experimental and observational skills, making chemistry more abstract and difficult to understand.

Another major issue is the lack of reliable electricity. Electricity is essential for many chemistry experiments, particularly those involving heating, electrolysis, and the use of electronic laboratory equipment such as balances. In rural areas, schools often experience frequent power outages or may not have access to electricity at all, as highlighted by Mkuzo and Govender (2024). This limitation prevents teachers from conducting a wide range of experiments and also restricts the use of multimedia teaching tools, such as videos and simulations, which could otherwise help explain complex concepts. Consequently, lessons remain largely theoretical and less engaging for learners.

Overcrowded and inadequate classrooms further complicate the teaching of chemistry. Many rural schools have large class sizes with limited space, making it difficult for teachers to organize practical activities or group work. As noted by Lembani (2021), overcrowding limits learners' ability to clearly observe demonstrations, and it becomes nearly impossible to conduct group experiments. To maintain classroom control, teachers often avoid practical lessons altogether, which reduces opportunities for active learning and participation.

The lack of proper storage and safety facilities is another critical infrastructural challenge. Chemistry requires secure storage for chemicals and apparatus, including cupboards, shelves, and locked rooms. Without these facilities, chemicals may deteriorate, be misplaced, or become hazardous. Shikalepo (2020) points out that poor storage conditions not only reduce the availability of usable materials but also increase safety risks. As a result, teachers may avoid conducting experiments due to concerns about accidents, and the lack of organized materials makes lesson preparation more difficult and less efficient.

Poor sanitation and ventilation also have serious implications for chemistry education. Many chemical experiments produce fumes, gases, or spills that require proper ventilation systems and sanitation facilities to ensure safety. In rural schools where such infrastructure is lacking, conducting experiments can be dangerous. This creates an unsafe learning environment for both teachers and learners, discouraging the use of practical activities. In some cases, teachers may completely avoid experiments involving gases or strong reactions, further limiting learners' exposure to important aspects of chemistry.

Beyond the physical limitations, poor infrastructure also has psychological effects on both teachers and learners. Inadequate facilities can lower teacher morale, as educators may feel frustrated and discouraged when they are unable to deliver lessons effectively. According to Shikalepo (2020), this often leads to reduced effort in preparing practical lessons and a reliance on basic teaching methods. For learners, the lack of engaging and interactive learning experiences can create negative perceptions of chemistry, making it seem difficult, uninteresting, and irrelevant. This reduces motivation and active participation in lessons, ultimately affecting academic performance.

Overall, infrastructural challenges in rural schools create significant barriers to effective chemistry education. The absence of laboratories, unreliable electricity, and overcrowded classrooms, lack of storage and safety facilities, and poor sanitation collectively hinder both teaching and learning. These factors not only limit practical engagement but also affect attitudes, motivation, and overall educational outcomes in chemistry.

3. Chapter Summary

The literature highlighted a variety of barriers to effective chemistry teaching in rural areas, including resource limitations, geographical isolation, and socio-economic factors. Addressing these challenges requires targeted interventions that involve collaboration among stakeholders. Future research should focus on evaluating the effectiveness of proposed solutions to ensure improvements in chemistry education in rural contexts.

III. Research Methodology

1. Introduction

This section explained the research design used, the target population, the sampling technique, the instruments that were used to collect data as well as the data collection methods and how the collected data analysed. This section also mentions the ethics that were considered throughout the study.

2. Research Design

A qualitative study research design was employed, focusing on a case study approach that allowed for an in-depth exploration of barriers to chemistry teaching in the selected rural schools. This design facilitated a comprehensive understanding of local contexts and challenges.

3. Research Site

The research was conducted in three secondary schools in Mumbi and Mwanjawantu zone in Petauke district of Zambia. The schools were Mondola, Mumbi and Mwanjabanthu secondary schools.

4. Study Population

The population will comprise

- Fifteen (15) Secondary school teachers who teach chemistry in Mumbi and Mwanjabantu zone,
- One hundred and ten (110) Grade twelve secondary pupils who learn chemistry

5. Target Population

Ten (10) Grade Twelve teachers who teach chemistry were targeted to ensure diverse perspectives while maintaining manageability for qualitative analysis.

Thirty (30) Grade twelve learners were targeted and interviewed

6. Sampling Procedure

Purposive sampling method was used to select the participants who had relevant experiences and the insights into chemistry teaching in rural areas. This included chemistry teachers and learners from selected rural schools. The rural schools were selected due to their;

- Flexibility
- Access to expertise
- Time and cost efficiency
- In-depth insight

7. Research Instruments

Semi- Structured Interview guide was the tool being used to collect data. Two different semi- structured interview guides were prepared, one was prepared for the teachers and another one was prepared for the learners.

8. Data Collection Procedures

Data was collected from three different secondary schools offering chemistry in the same rural contexts in three zones so as to strengthen the credibility and reliability of the results, that also helped with the richness and depth of the findings, contributing to a more comprehensive understanding of the study.

9. Data Analysis

The qualitative data collected through the semi-structured interviews was analysed thematically using NVIVO -15 software

10. Ethical Consideration

Ethical considerations were carefully observed throughout the study to ensure that the rights, dignity, and well-being of all participants were protected. Prior to the commencement of the research, ethical approval was sought and obtained from the relevant education authorities. This step ensured that the study complied with established research standards and institutional guidelines, particularly those governing research involving human participants in educational settings. Seeking such approval also demonstrated respect for regulatory frameworks and provided assurance that the study was conducted responsibly and professionally.

In addition, the principle of honesty and transparency was upheld during the research process. Participants were clearly informed about the purpose and objectives of the study, as well as the procedures involved in data collection. They were made aware of what their participation would entail and were given the opportunity to ask questions or seek clarification where necessary. Importantly, participants were informed of their right to withdraw from the study at any stage without facing any negative consequences. This ensured that participation was entirely voluntary and free from any form of coercion or pressure.

Confidentiality was another key ethical consideration in the study. Participants were assured that all information they provided would be treated with strict confidentiality. Their identities were protected by ensuring that no personal details were disclosed in the reporting of the findings. Data collected from participants were handled securely and used solely for the purposes of the research. This helped to build trust between the researcher and participants, encouraging honest and open responses.

Furthermore, informed consent was obtained from all participants before the data collection process began. This involved providing participant with clear and comprehensive information about the study, including its aims, methods, potential risks, and benefits. Participants were required to indicate their willingness to take part, confirming that they fully understood the nature of the research. This process ensured that participants made informed decisions regarding their involvement, thereby upholding ethical standards and respecting their autonomy.

11. Work Plan/ Time Schedule (Line)

The scheduled time allocated for the study was three months that is from January 2026 to April, 2026 when the schools would close for term one. That was so to allow comprehensive data collection and analysis, the time scheduled for the study helped with the elimination of possible threats to the validation and credibility of the research work

12. Conclusion

Chapter Three provided a comprehensive overview of the research methodology utilized to investigate the barriers to effective chemistry teaching in rural areas, specifically through the case study of three secondary schools in Mumbi and Mwanjawantu Zone. A qualitative methods approach was employed incorporating qualitative techniques to ensure a holistic in-depth understanding of the challenges faced by educators and students. The data collection process included interviews with teachers. This approach allowed for triangulation of data, strengthening the validity of the findings. The chapter also addressed ethical considerations and limitations inherent in the research design, emphasizing the importance of maintaining confidentiality and ensuring informed consent among participants. The methodology outlined in this chapter lays a firm foundation for the subsequent presentation of findings and discussions. It prepares the ground for a nuanced understanding of the barriers to effective chemistry teaching and the potential solutions that can be explored in the following chapters.

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IV. Presentation, Interpretation and Analysis

1. Introduction

This chapter presented and discussed the findings of the study on the barriers to effective teaching of chemistry in rural secondary schools. The data were collected through semi- structured interviews with chemistry teachers and learners. The findings were presented according to themes that emerged from their responses.

2. Participant`S Background Information

The study involved chemistry teachers and the learners. Most teachers had several years of teaching experience but reported working under challenging conditions.

3. Demography of the Respondents

This section presents the demographic profile of the respondents who participated in the study. The study involved 10 chemistry teachers and 30 learners from selected rural secondary schools.

Demographic Characteristics of Teachers (n = 10)

The demographic variables considered for teachers included gender, age, teaching experience, academic qualifications, and years of service in rural schools.

Table 1: Gender distribution of teachers

Gender	Frequency	Percentage
Male	6	60
Female	4	40
Total	10	100

Interpretation

The findings from according to table 4.1 show that the majority of teachers (60%) were male, while 40% were female.

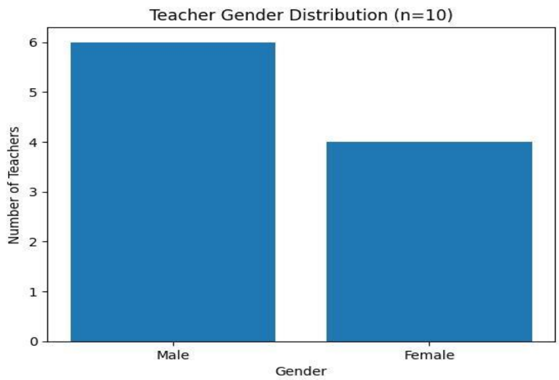


Figure 1: Gender teacher distribution

Interpretation

Figure 4.1 shows the gender distribution of the participating teachers. The results indicate that 6 out of 10 teachers (60%) were male, while 4 teachers (40%) were female. This suggests that male teachers slightly outnumber female teachers in the sampled rural secondary schools.

The relatively balanced representation of male and female teachers enhances the credibility of the study, as perspectives from both genders were included. However, the higher proportion of male teachers may reflect broader staffing patterns in rural schools, where female teachers may be less represented due to challenges such as relocation, family commitments, or limited deployment to remote areas. Gender distribution is important in understanding teaching dynamics, as previous research suggests that teacher gender may influence instructional approaches and classroom engagement patterns.

Table 2: Age distribution of teachers

Age Range	Frequency	Percentage
25-30	2	20
31-40	4	40
41-50	3	30
51+	1	10
Total	10	100

Interpretation

According to table 4.2 Most teachers (40%) were between 31–40 years, indicating a relatively mature teaching workforce.

Table 3: Teaching experiences

Years of Experience	Frequency	Percentage
1-5 years	3	30
6-10 years	4	40
11-15 years	2	20
16+ years	1	10
Total	10	100

Interpretation

Most teachers had between 6–10 years of experience.

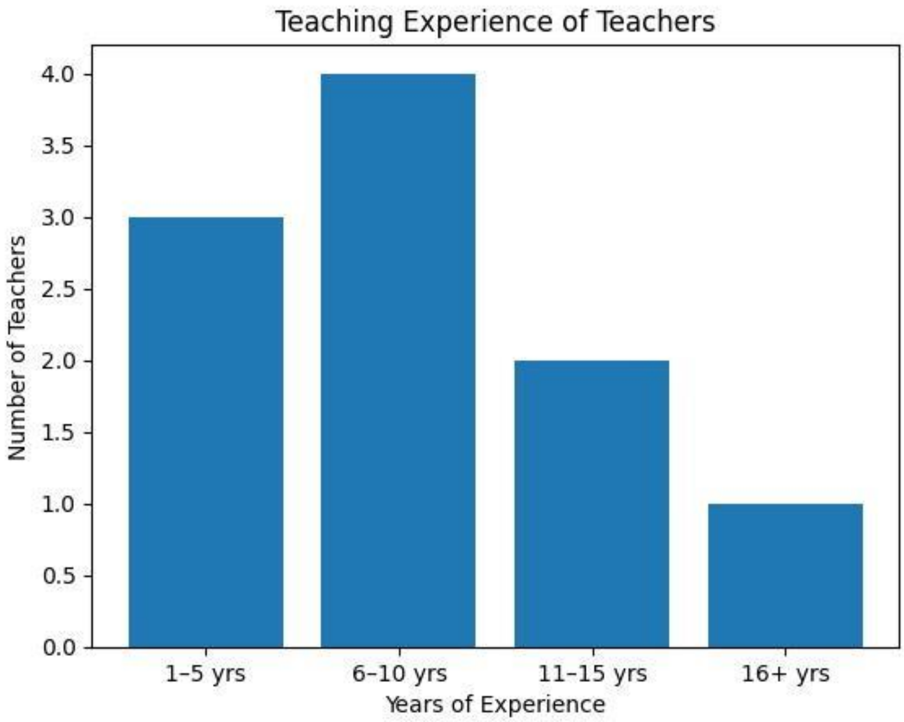


Figure 2: teaching experience

Interpretation

Figure 4.2 presents the distribution of teachers according to their years of teaching experience. The findings reveal that the majority of teachers (4 teachers, 40%) had between 6–10 years of teaching experience. Three teachers (30%) had 1–5 years of experience, while 2 teachers (20%) had 11–15 years of experience. Only one teacher (10%) had more than 16 years of experience.

These findings indicate that most teachers in the study possess moderate teaching experience. This is significant because teaching experience can influence instructional effectiveness, classroom management, and the ability to improvise in resource-limited environments. Teachers with more years of experience may be better equipped to adapt to rural challenges; however, limited professional development opportunities in rural areas may reduce the impact of experience on innovative teaching practices. The presence of relatively fewer highly experienced teachers may also suggest teacher turnover in rural schools.

Table 4: Academic qualifications

Qualification	Frequency	Percentage
Diploma in science education	3	30
Bachelor`s degree in science education -chemistry	7	70
Total	10	100

Interpretation

Table 4.4 showed that the majority (60%) held Bachelor’s degrees in Chemistry or Science Education.

Table 5: Years serving in rural schools

Years In Rural School	Frequency	Percentage
1-3 years	4	40
4-6 years	3	30
7+ years	3	30
Total	10	100

Interpretation

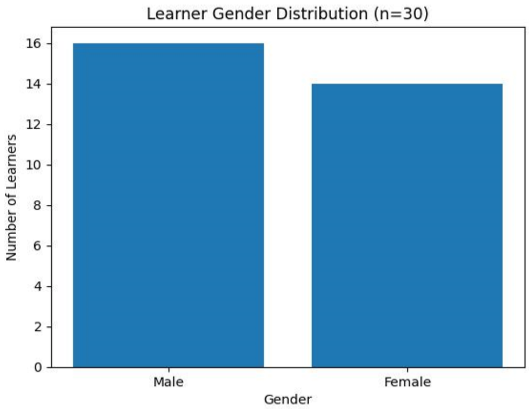
Most teachers had at least three years of experience teaching in rural settings.

Demographic Characteristics of Learners (n = 30)

The demographic variables for learners included gender, grade level, age, and distance travelled to school.

Table 6: Gender distribution of learners

Gender	Frequency	Percentage
Male	16	53
Female	14	47
Total	30	100



Interpretation

Figure 4.3 illustrates the gender distribution among learners who participated in the study. Out of 30 learners, 16 (53%) were male and 14 (47%) were female. The distribution is relatively balanced, with only a slight predominance of male learners.

This balanced representation is important in ensuring that the study captures diverse learner experiences regarding chemistry learning in rural schools. The near-equal participation suggests that both male and female learners are enrolled in chemistry at comparable rates in the sampled schools. However, further investigation would be necessary to determine whether gender differences exist in performance, participation, or attitudes toward chemistry within the rural context.

Table 7: Age distribution of learners

Age Range	Frequency	Percentage
15-16	8	27
17-18	18	60
19+	4	13
Total	30	100

Interpretation

The majority of learners (60%) were aged between 17–18 years.

Table 8: Distance travelled to school

Distance	Frequency	Percentage
Less than 2 km	6	20
2-5 km	14	47
More than 5 km	10	33
Total	30	100

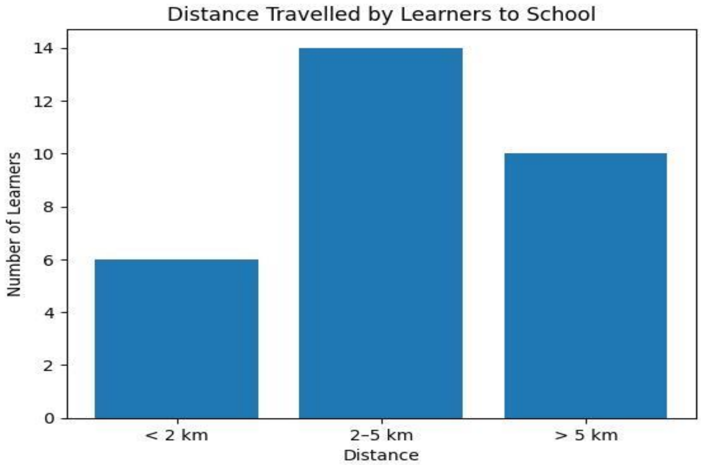


Figure 4 Distance travelled by learners to school

Interpretation

Most learners (47%) travelled between 2–5 km to school daily, while 33% travelled more than 5 km.

Interpretation

Figure 4.4 shows the distance learners travel daily to attend school. The findings reveal that 14 learners (47%) travel between 2–5 km, while 10 learners (33%) travel more than 5 km. Only 6 learners (20%) travel less than 2 km.

These results indicate that a significant proportion of learners travel long distances to access schooling. Long travel distances can contribute to fatigue, reduced concentration in class, and limited time for homework or revision. This is particularly important in the context of chemistry education, which requires sustained concentration and after-class study. Learners who walk long distances may arrive late or tired, negatively affecting participation in practical lessons and overall academic performance. The findings therefore provide contextual insight into how geographical and infrastructural challenges may indirectly affect chemistry learning outcomes.

Overall Demographic Implication

The demographic characteristics of respondents provide important contextual background for interpreting the study findings. The moderate teaching experience, balanced gender representation, and significant travel distances collectively highlight structural conditions that may influence the effectiveness of chemistry teaching and learning in rural schools.

Summary of Demographic Findings

The demographic results indicate that:

- The teacher population is moderately experienced and academically qualified.
- Most teachers have significant exposure to rural teaching conditions.
- Learners are predominantly in senior secondary grades.
- A significant proportion travel long distances to school, which may influence fatigue and academic performance.

These demographic characteristics provide important context for understanding the barriers to effective chemistry teaching in rural schools.

4. Findings for Each Research Question

Thematic Analysis of Interview Responses

After conducting interviews with teachers and learners, responses were code and grouped into categories. Similar ideas were combined to form sub- themes, which were then organized into the four major themes of the study

Theme 1: Resource Limitations

Table 9: Resource limitation

Sample responses from participants	Codes	Sub- theme	Major theme
"we don't have enough chemicals for experiments	Lack of chemicals	Inadequate laboratory materials	Resource limitation
"Learners share textbooks during lessons"	Shortage of textbooks	Inadequate learning materials	Resource limitation
We teach practical topics on the chalkboard	No practical work	Lack of experiments	Resource limitation
Apparatus is old and broken	Worn out equipment	Poor lab equipment	Resource limitation

Interpretation

Teaching becomes theoretical: learners fail to gain practical skills

Participants consistently highlighted shortages of essential teaching and learning resources such as chemicals, apparatus, textbooks and visual aids

Teacher's views:

"most of the chemistry topics are taught theoretically due lack of chemicals and materials"

Learner's views:

" most of the chemistry topics are taught theoretically due lack of chemicals and materials"

V. Discussion

Chemistry is a practical subject that requires experiments and demonstrations. The lack of materials and chemicals forces teachers to rely on explanations rather than hand-on learning, leading to poor conceptual understanding and reduced learner interest.

Socio-Economic Factors

Socio- economic conditions of learners and their families were reported as a major barrier

Theme 2: Socio-Economic Factors

Table 10: Socio-economic factors

Sample responses from participants	Codes	Sub- theme	Major theme
Learners come tired from doing farm work	Fatigue	Household responsibilities	Socio-Economic Factors
Some learners do not have textbooks at home	No learning materials	Poverty	Socio-Economic Factors
There is no electricity for studying at home	No study time	Poor home environment	Socio-Economic Factors
Absenteeism is common during farming season	Irregular attendance	Family economic activities	Socio-Economic Factors

Theme 3: Geographical Isolation

Table 11: Geographical isolation

Sample responses from participants	Codes	Sub- theme	Major theme
We rarely attend workshop due to distance	No workshops	Limited professional development	geographical isolation
It takes long to get laboratory supplies	Delayed supplies	Poor access to resources	geographical isolation
the school has poor internet connectivity	Poor internet	Isolation from digital world	geographical isolation

Discussion

Poverty limits access to learning materials and adequate study time at home. Some learners lack electricity for studying at night and others prioritize household responsibilities over schoolwork, which negatively affects the performance in chemistry.

The location of the rural schools is far from town and other educational centres was another key barrier

Teacher`s view

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Discussion

Geographical isolation limits teachers access to professional development, science workshop, and supply centres where laboratory materials can be purchased. This isolation slows the improvement of teaching practices and resource acquisition

Theme 4: Infrastructure challenges

Participants described the poor school infrastructure as a serious hindrance

Table 12: Infrastructure challenges

Sample responses from participants	codes	Sub- theme	Major theme
There is no proper laboratory room	No lab	Lack of lab space	Infrastructure challenges
Classrooms are overcrowded	Large class size	congestion	Infrastructure challenges
Classrooms are poorly lit and ventilated	Poor learning environment for chemistry	Inadequate classrooms	Infrastructure challenges

Interpretation

Environment does not support practical chemistry learning

Teachers view

> "There is no proper laboratory room, we use a normal classroom"

Learner`s views:

> "There is no proper laboratory room, we use a normal classroom"

Discussion

Poor buildings, lack of laboratory rooms, insufficient furniture, lack of water supply and no electricity make it difficult to conduct practical chemistry lessons. Overcrowded classrooms reduce effective interaction between teachers and learners.

Impact of the identified barriers on the teaching and learning of chemistry

The four major barriers identified in this study do not operate in isolation, they directly affect teachers teach and how learners understand chemistry in rural secondary schools.

Cross- cutting theme: effects on teaching and learning

Table 13: Effects on teaching and learning

Observed outcome	Source from responses
Teaching becomes lecture-based	Lack of lab and materials
Learners memorize instead of understanding	No practical exposure
Negative attitude towards chemistry	Perceived difficulty and poor experience
Low interest in taking chemistry further	Lack of motivation and support

Interpretation

The table 4.13 above shows how these barriers affect effective chemistry education.

Tally of responses from participants (n=40) is shown below

Table 14: frequency of responses of barriers

Major barrier	Teachers (n=10)	Learner (n=30)	Total mentions	interpretations
Resource limitation	10	24	34	Most critical barrier affecting chemistry teaching
Socio-economic factors	7	21	28	Strongly affects learners` study and participation
Geographical isolation	6	14	20	Limit access to support and opportunities
infrastructure	8	18	26	Learning environment not suitable for practical work

Interpretation

A table 4.14 shows the frequency with which participants mentioned each barrier. These tallies were then used to generate the charts presented in figures 4.6

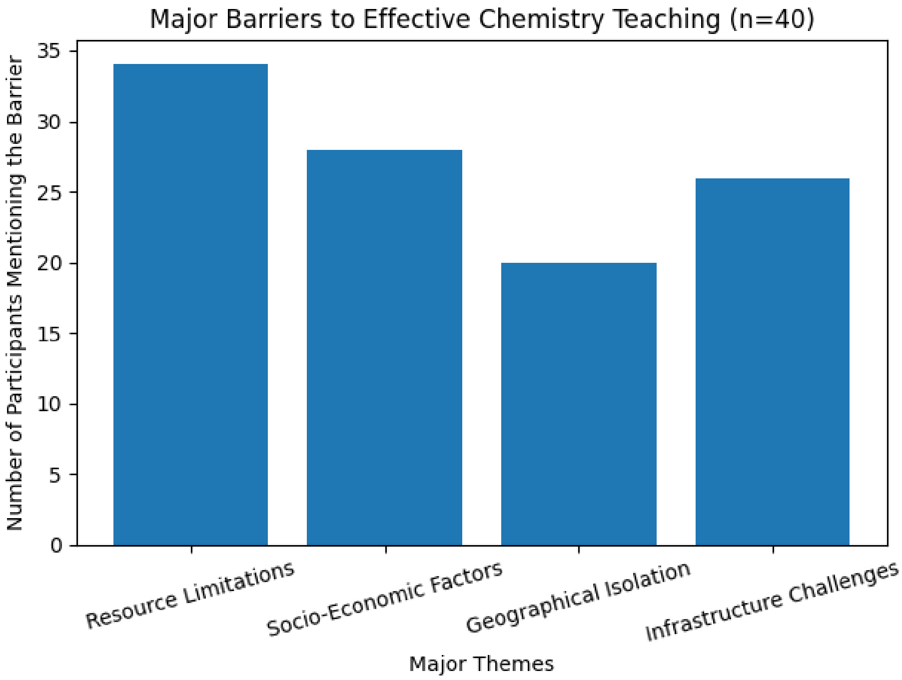

Figure 5: Major barriers to effective chemistry teaching

Interpretation

Figure 4.5 shows that resource limitations were the most frequently mentioned barrier, followed by socio-economic factors, infrastructure challenges and geographical isolation. This indicates that lack of teaching and learning materials is the most pressing challenge affecting chemistry teaching in rural schools.

Resource limitations have a significant impact on the teaching of chemistry, particularly in rural schools where essential materials and facilities are often lacking. In such environments, teachers are forced to rely heavily on theoretical explanations instead of conducting experiments, which are essential for effective chemistry instruction. This shift limits the use of activity-based teaching approaches and results in lessons becoming predominantly teacher-centred. Furthermore, teachers face difficulties in explaining abstract concepts such as chemical reactions, titration, and gas preparation without the aid of practical demonstrations. As a result, the quality of instruction is reduced, and learners are deprived of meaningful, hands-on learning experiences.

These limitations in teaching directly affect the learning process. Learners tend to rely on memorization rather than true understanding of concepts, as they are unable to observe or engage with experiments. This leads to poor development of practical and investigative skills, which are essential in chemistry. Additionally, the lack of engaging, experiment-based lessons reduces learners' interest and motivations, making the subject appear difficult and less appealing.

Socio-economic factors further compound these challenges and influence both teaching and learning. From a teaching perspective, teachers are often required to spend more time re-teaching concepts because learners are unable to study effectively at home due to lack of resources. Irregular attendance and lateness, often caused by household responsibilities or financial constraints, disrupt the continuity of lessons and make it difficult for teachers to progress with the syllabus. This creates additional pressure on teachers and limits the effectiveness of instruction.

From the learners' perspective, socio-economic challenges significantly hinder academic progress. Many learners lack adequate time and space for studying due to household duties and poor living conditions. Fatigue and stress from these responsibilities reduce their ability to concentrate during lessons. Moreover, the inability to afford textbooks and other learning materials limits opportunities for practice and revision, resulting in gaps in understanding and poor retention of knowledge.

Geographical isolation also plays a critical role in shaping the quality of chemistry education. Teachers in remote areas often have limited access to professional development opportunities such as workshops and training programs, which restricts their exposure to new teaching methods and innovations. In addition, delays in the delivery of chemicals and laboratory apparatus further hinder effective teaching. Professional isolation reduces collaboration with other educators, leading to limited sharing of ideas and decreased innovation in teaching practices.

For learners, geographical isolation results in exposure to outdated teaching approaches and limited access to enriching academic experiences. Many rural learners are unable to participate in science fairs, competitions, and other external learning opportunities that enhance understanding and stimulate interest in chemistry. This lack of exposure reduces their academic engagement and limits their ability to connect classroom learning with broader scientific contexts.

Infrastructure challenges also have a profound impact on both teaching and learning. From a teaching perspective, overcrowded classrooms make it difficult to organize practical lessons and manage learners effectively. Poor lighting, inadequate ventilation, and limited space hinder the ability to conduct clear and safe demonstrations. In addition, the lack of water supply and proper laboratory facilities prevents teachers from carrying out experiments altogether, further restricting practical instruction.

For learners, these infrastructural challenges create an unfavourable learning environment. Overcrowding makes it difficult for learners to clearly observe demonstrations, while poor classroom conditions reduce participation and engagement. Increased distractions in such environments further limit concentration and understanding, negatively affecting overall learning outcomes.

The combined effects of resource limitations, socio-economic challenges, geographical isolation, and poor infrastructure significantly hinder the teaching and learning of chemistry. These barriers contribute to poor conceptual understanding of the subject, as learners are unable to fully grasp key concepts without practical exposure. They also lead to the development of fear and negative attitudes toward chemistry, making learners less likely to engage with the subject. In addition, learners develop lower levels of practical competence, which affects their ability to perform in laboratory-based assessments. Ultimately, these challenges result in poor examination performance and limit learners' opportunities for further study and careers in science-related fields.

Tally of effects on teaching and learning (n=40)

Table 15: Frequency of responses on teaching and learning

Observed Effect	Teachers (n=10)	Learner (n=30)	Total mentions	meaning
Lecture-based teaching	9	21	30	Practical work replaced by theory
Memorization instead of understanding	8	19	27	Poor conceptual learning
Negative attitudes towards chemistry	6	19	25	Learners fear and dislike the subject
Poor examination performance	10	22	32	Low achievement in chemistry
Low subject uptake	7	15	22	Few learners choose chemistry at higher level

Interpretation

Table 4.15 shows the frequency with which participants mentioned the effect of each barrier. The tallies were obtained during coding of interview responses. These tallies were then used to generate the charts presented in figures 4.6

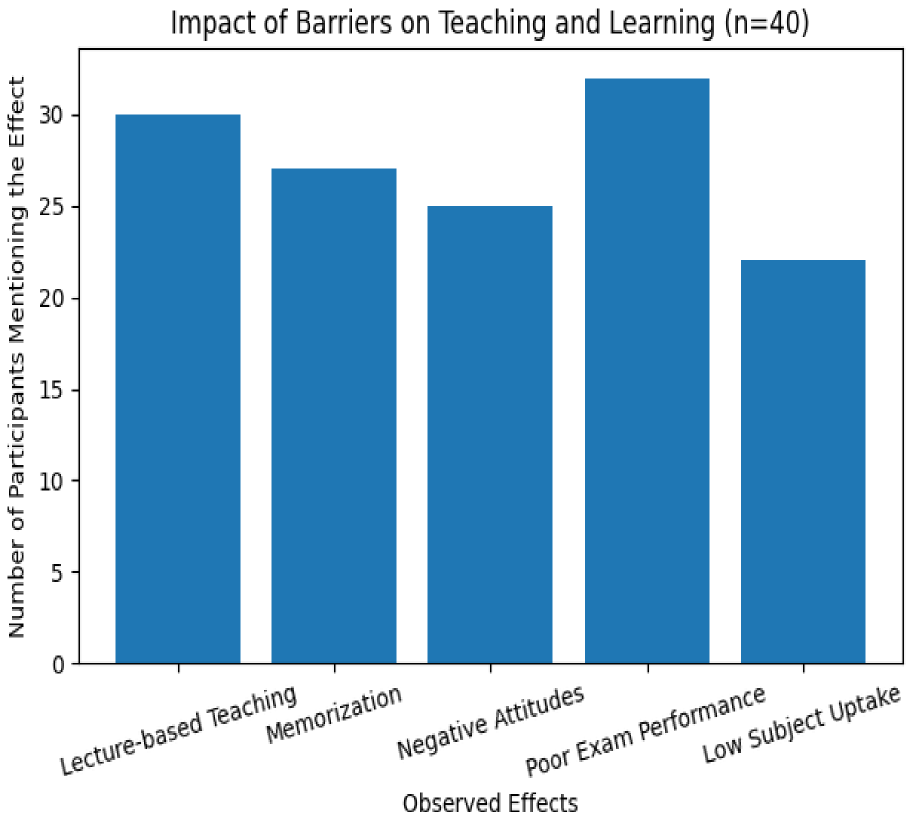

Figure 6: Impact of barriers on teaching and learning

Interpretation

Figure 4.6: illustrates the barriers mainly results in poor examination performance, lecture- based teaching and memorization instead of understanding. This confirms that the presence of practical learning and supportive conditions negatively affects learners` comprehension of chemistry.

Summary of thematic flow

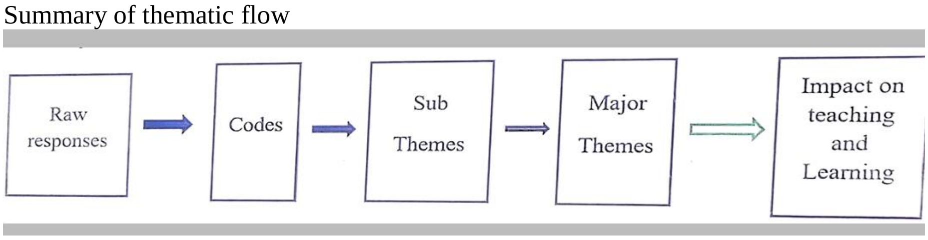

Figure 7: summary of the thematic flow

Interpretation

Figure 4.7 shows how the responses from the interviews on the barriers to effective chemistry teaching in rural areas were analysed into codes and the related codes were grouped into common major themes to show the impact of these themes on chemistry teaching and learning in the rural areas.

5. Chapter Summary

This chapter presented, interpreted and discussed the findings according to the major themes that emerged from the data. The next chapter presents the conclusions and the recommendations of the study.

V. Conclusions and Recommendations

1. Introduction

This chapter presents the conclusions drawn from the findings of the study and provides recommendations aimed at addressing the barriers to effective teaching and learning of chemistry in rural secondary schools.

2. Conclusion

The study set out to investigate the barriers to effective chemistry teaching in rural secondary schools. Findings from interviews with teachers and learners revealed that chemistry teaching is greatly affected by four major barriers:

- Resource limitations
- Socio-economic factors
- Geographical isolation
- Infrastructure challenges

These barriers negatively influence both the teaching process and the learning process.

Due to inadequate laboratory equipment, chemicals, and textbooks, teachers are forced to teach chemistry theoretically rather than practically. This denies learners the opportunity to develop practical skills and deep conceptual understanding. Socio-economic challenges limit learners' study time, access to learning materials, and concentration in class. Geographical isolation prevents teachers from accessing professional development opportunities and delays the acquisition of laboratory supplies. Poor infrastructure, including lack of laboratories, overcrowded classrooms, and inadequate water supply, further complicates practical chemistry lessons.

The combined effect of these barriers results in poor learner attitudes toward chemistry, low interest, poor performance in examinations, and reduced uptake of the subject at higher levels.

Therefore, without addressing these challenges, effective chemistry teaching and meaningful learning in rural schools will remain difficult to achieve.

3. Recommendations

Based on the findings, the study makes several key recommendations aimed at improving the teaching and learning of chemistry, particularly in rural schools. Firstly, there is a need for the provision of adequate laboratory resources. The Ministry of Education should prioritize the supply of essential chemicals, apparatus, and laboratory equipment to rural schools, while also supporting institutions in establishing fully functional science laboratories. Where resources are limited, the improvisation of locally available materials for experiments should be encouraged to enhance practical learning.

In addition, improvement of school infrastructure is necessary. The government and other stakeholders should invest in constructing and renovating laboratory facilities, as well as expanding classrooms to reduce overcrowding. Ensuring a reliable water supply is also crucial for effective science practical work. Furthermore, teacher professional development should be strengthened through the organization of regular workshops and in-service training for chemistry teachers.

The study also emphasized the importance of supporting learners from low socio-economic backgrounds. This can be achieved through the provision of textbooks and other learning materials, as well as the introduction of study support initiatives such as remedial lessons. Community sensitization programs should also be implemented to highlight the importance of supporting learners in science subjects.

Addressing geographical isolation is critical. This can be done by strengthening partnerships between under-resourced schools and nearby well-equipped schools, introducing mobile laboratory programs and outreach science initiatives, and improving road networks alongside providing transport support for schools in remote areas. Furthermore, there is a need to improve network and internet services in rural schools. The government and relevant stakeholders should invest in expanding reliable internet connectivity to ensure that both teachers and learners can access digital educational resources, online experiments, and virtual laboratories. Improved network services will also support e-learning platforms, teacher training programs, and communication between schools. Providing affordable or subsidized internet access, along with the necessary digital devices, will greatly enhance the integration of technology in science education and help bridge the gap between rural and urban schools.

In addition, increased funding for rural education should be prioritized. The government should allocate more financial resources specifically targeted at improving science education in rural schools, including funding for laboratory equipment, infrastructure development, and teaching materials. Transparent and equitable distribution of funds should be ensured to address disparities between rural and urban schools. Partnerships with non-governmental organizations, private sector stakeholders, and community initiatives should also be encouraged to supplement government efforts. Adequate and sustained funding will play a crucial role in improving the quality of education and ensuring that learners in rural areas have equal opportunities to succeed in science subjects.

4. Recommendations For Further Research

Further research can build on this study in several important ways. A similar study can be conducted using a quantitative approach to measure the extent and magnitude of the barriers affecting the teaching and learning of chemistry in rural schools. Such an approach would allow researchers to collect numerical data, analyse trends, and establish relationships between variables such as resource availability, teacher qualifications, and learner performance.

In addition, research can be carried out on effective strategies for improvising chemistry apparatus using locally available materials. This would help develop practical, low-cost solutions that teachers can use in resource-limited settings, thereby improving learners' hands-on experience in science.

Furthermore, further studies can be carried out to explore the impact of technology on the teaching of chemistry in rural schools, particularly focusing on how digital tools, virtual laboratories, and online learning platforms can enhance understanding and engagement. Investigating these areas would provide deeper insights and practical interventions to address the challenges faced in rural science education.

5. Chapter Summary

This chapter provided the conclusions and recommendations of the study. The study has shown that addressing resource, socio-economic, geographical, and infrastructural challenges is essential for improving the teaching and learning of chemistry in rural secondary schools.

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