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RESEARCH ARTICLE

SCHOOL INFRASTRUCTURE DEVELOPMENT FOR CHEMISTRY EDUCATION AND PUPILS LEARNING OUTCOMES IN CHEMISTRY SUBJECT IN PUBLIC SECONDARY DAY SCHOOLS IN RWANDAA CASE OF RUTSIRO DISTRICT

Nyirarukundo Agnes[1] and Dr. Hesbon O. Andala[2]
1. MED Student, Mount Kenya University, Rwanda.
2. Senior Lecturer, Mount Kenya University, Rwanda.

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Abstract

This research examined students' learning results in chemistry courses in public higher-day schools in Rwanda as well as the creation of infrastructure for chemistry education in those schools. In particular, the study defined the infrastructure development for chemistry education in Rwandan public secondary day schools, examined the impact of this infrastructure development on students' chemistry learning outcomes, and ascertained the correlation between the two. The study used both qualitative and quantitative techniques in a mixed-methods approach. A total of 662 respondents, comprising 175 instructors and 483 pupils in Rutsiro District, 1 District Director of Education, 1 District Education Officer, and 2 Sector Education Inspectors, were the study's target population. Using Slovin's formula, the researcher calculated the sample size of 249 respondents. A pilot study was taken into consideration, and questionnaires and documentation research procedures were employed as instruments of data collecting. Respondents were selected by purposive selecting for district education officials and random sampling for students and instructors. SPSS version 21 was used to evaluate the data, and conclusions were drawn from the responses provided by the participants. Regarding the first objective, the findings show that: 95.3% of respondents either strongly agreed or agreed that the chemistry education infrastructure in public secondary schools is well-developed and used effectively; 90.5% of respondents agreed or strongly agreed that facilities and the infrastructure required for chemistry education are available for learning and teaching chemistry subjects in public secondary schools; and 85.7% of respondents agreed or strongly agreed that chemistry teachers in public secondary schools are properly trained to use laboratory equipment in conducting scientific experiments in chemistry subjects. Regarding the second goal, the study finds that 98.2% of respondents strongly agreed or agreed that your school's chemistry students now learn more in their classes due to the laboratories and equipment that the schools have developed for chemistry education; 82.1 percent strongly agreed or agreed that having well-functioning schools has improved students' attention to chemistry concepts; and 85.2 percent strongly agreed or

Corresponding Author:-Nyirarukundo Agnes
Address:-MED Student, Mount Kenya University, Rwanda.

agreed that students now have more access to chemistry-related educational resources and materials because of the development of schools' infrastructure for chemistry education. Since the p-value for the third aim, which is the creation of school infrastructure for chemistry teaching, is less than 0.05, the results have a positive significance for students' learning outcomes in chemistry. The development of chemistry education infrastructure in Rwanda is crucial for students' learning outcomes. Recommendations include establishing well-equipped laboratories with modern equipment, ensuring safety measures, designating classrooms for chemistry education, stocking the school library with relevant resources, building a central science laboratory, providing teacher training, collaborating with educational authorities to develop a curriculum aligned with international standards, and establishing a system for assessing students' progress in chemistry. These measures will help improve the country's chemistry education infrastructure and support students in achieving better learning outcomes. The researcher suggested that the next study should focus on addressing gender disparities in chemistry education strategies to promote gender equity in public secondary schools.

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Introduction:-

Schools' infrastructure development for chemistry education refers to planning, constructing, improving, and maintaining physical facilities and resources within educational institutions that enhance chemistry (Kapur 2019). It encompasses the development and enhancement of various components that contribute to the physical infrastructure of schools, including buildings, classrooms, laboratories, libraries, sports facilities, technology infrastructure, and other supporting amenities

At International Outlook in Germany, constructing, renovating, or expanding school buildings to accommodate classrooms, administrative areas, libraries, laboratories, sports facilities, auditoriums, and other necessary spaces, ensuring classrooms are well-designed and equipped with appropriate furniture, lighting, ventilation, and acoustics to provide a suitable learning environment for students Forschung (2021).

Technology integration is also encouraged, with the availability of multimedia resources and interactive whiteboards. German schools adhere to Safety Standards, to strict safety standards in chemistry classrooms and laboratories, Safety protocols and guidelines are in place to ensure the well-being of students and teachers during practical sessions, minimizing potential risks associated with chemical experiments. Reported by Sicherheit, (2021)

Germany's extensive public school system, Education so typically occurs within a school's physical infrastructure, although there are also some private exchanges among pupils, educators, and pedagogical content. The physical facilities have a significant influence on kids' enrollment, attendance, completion rates, and even academic success. As stated by UNICEF 2020, At the regional level, according to Kimemia (2019), the students in classrooms with suitable infrastructure showed higher levels of engagement and better performance in chemistry subjects. In Kenya, school infrastructure development plays a crucial role in shaping pupils' learning outcomes in the chemistry subject. The availability of appropriate infrastructure can significantly impact students' engagement, understanding, and achievement in chemistry. Some key points to consider, are laboratory Facilities, Chemistry students get the chance to participate in practical demonstrations and hands-on experiments in well-equipped laboratories. They provide students the opportunity to apply theoretical ideas, hone their critical thinking abilities, and expand their knowledge of chemistry. Access to functional laboratory facilities positively influences students' performance in chemistry, and the physical environment of classrooms can impact students' learning experiences. Adequate lighting, ventilation, and comfortable seating arrangements contribute to a conducive learning environment. According to Otieno (2018),

There is a positive impact of resource availability on students' performance in chemistry subject. Availability of resources, and access to relevant textbooks, reference materials, and digital resources is essential for students to study and comprehend chemistry topics. Well-stocked libraries and access to online resources enhance students' ability to explore the subject further.

Infrastructure that supports the practical application of chemistry concepts, such as access to field trips, industry visits, and guest lectures, can enhance students' understanding of real-world applications of the chemistry subject. Practical experiences foster a deeper connection between theoretical knowledge and its practical relevance. According to Macharia (2017),

The teacher's competence significantly influenced students' achievement in chemistry. Teacher Competence, while infrastructure is important, the quality of teaching remains a critical factor. Well-trained chemistry teachers who possess subject knowledge and pedagogical skills can effectively deliver lessons and engage students in learning According to Kariuki et al (2020),

It's worth noting that while infrastructure development for chemistry education is essential, it is just one component of a comprehensive approach to improving learning outcomes in chemistry. Other factors, including curriculum design, teaching methodologies, student motivation, and parental involvement, also contribute significantly to students' achievements in the subject.

The specific impact of infrastructure development on pupils' learning outcomes in the chemistry subject in Kenya may vary based on various contextual factors and the specific initiatives implemented. To improve teacher competence in chemistry, several strategies can be implemented by focusing on Professional Development Programs, by providing regular and targeted professional development opportunities for chemistry teachers is essential.

At local outlook, the study of Ntakirutimana (2019), reported that school infrastructure development for chemistry education in Rwanda has been a priority for the government, aiming to improve the learning environment and enhance educational outcomes. Efforts have been made to upgrade existing facilities and construct new classrooms, laboratories, libraries, and other essential infrastructure components. In terms of chemistry subject learning outcomes, various factors influence student achievement, availability of well-equipped chemistry laboratories is essential for practical demonstrations and experiments. Access to modern laboratory equipment, chemicals, and safety measures enables students to participate in practical learning activities and get a greater comprehension of chemical principles, Classroom Environment, a conducive classroom environment with appropriate lighting, ventilation, and comfortable seating can positively impact students' engagement and concentration during chemistry lessons.

Teachers' subject knowledge, pedagogical skills, and instructional strategies significantly influence pupils' learning outcomes in chemistry subjects Continuous professional development programs for chemistry teachers can enhance their teaching effectiveness, content knowledge, and ability to deliver engaging and effective lessons. According to Gatera (2020),

The curriculum design and assessment (Republic of Rwanda Ministry of Education 2015), including the content, pedagogical approaches, and assessment methods, plays a crucial role in shaping students' learning outcomes. A well-structured curriculum that aligns with national standards and emphasizes practical applications of chemistry can contribute to improved pupils ‘learning outcomes in chemistry subject.

The efforts to enhance school infrastructure and learning outcomes in chemistry have been recognized and supported by various stakeholders in Rwanda. The government's commitment to providing conducive learning environments and access to quality resources highlights the importance placed on promoting scientific literacy and excellence in chemistry education.

The main objective of this research was to evaluate school infrastructure Development for Chemistry Education and Pupils' Learning Outcomes in Chemistry Subjects in Public Secondary Day Schools in Rwanda.

This study was guided by the following specific objectives:

1. To assess schools’ infrastructure development for chemistry education in public secondary day schools in Rwanda.

2. To analyze the pupils' learning outcomes in chemistry subjects that are due to the schools' infrastructure development for chemistry education in public secondary day schools in Rwanda.
3. To determine the relationship between the schools' infrastructure development for chemistry education and pupils learning outcomes in chemistry subjects in public secondary day schools in Rwanda.

Literature Review:-

Theoretical Literature

According to Anderson (2022), to have a thorough grasp of a study issue, a theoretical literature review analyzes and synthesizes current theoretical frameworks and models in a methodical manner. A theoretical literature evaluation leads to the creation of new theoretical insights and lays the groundwork for future research by analyzing and combining these theories (Jones 2020).

Concept of Schools 'Infrastructure Development in Chemistry subject

According to Smith (2024), school infrastructure development in chemistry subjects refers to physical facilities, buildings, resources, and equipment that are essential for providing education and supporting the learning environment within schools. It encompasses a wide range of components including classrooms, laboratories, libraries, administrative offices, recreation areas, and technology infrastructure. Facilities for Labs Schools must have labs for biology, chemistry, and physics. The labs serve mainly as the infrastructure of the schools to improve the learning outcomes of students in chemical topics for experiments, and they are equipped with a variety of science-related machinery, instruments, apparatuses, and equipment. labs. There has been laboratory construction.

Pupils learning outcomes

Pupil learning outcomes, according to Freeman (2020), are the particular information, abilities, attitudes, or competences that students are expected to gain or exhibit as a result of their educational experiences. These goals frequently outline the knowledge, skills, and abilities that students need to possess following a course, program, or instructional activity. These outcomes reflect the measurable achievements and progress of the students in their academic and personal development. Theoretical perspectives that inform the understanding of students' learning outcomes.

Empirical Review

Schools' infrastructure development for chemistry education has highlighted its positive impact on various aspects of education, including pupils' learning outcomes in chemistry subject. Some key findings commonly observed in empirical studies on schools' infrastructure development for chemistry education include academic Achievement, schools with improved infrastructure, including well-designed classrooms, libraries, and technology resources, and well-equipped chemistry laboratories have been associated with better learning outcomes among pupils as reported by Bascia(2019). Attendance and Engagement, Adequate infrastructure, such as comfortable and safe learning environments, can contribute to increased student attendance rates and engagement in the learning process (UNESCO, 2017).

Schools with upgraded infrastructure often report improved teacher morale, job satisfaction, and effectiveness, leading to enhanced student learning outcomes (UNESCO, 2017). Access to quality infrastructure in schools helps reduce disparities and promote educational equity, ensuring that all students, regardless of their background, have equal opportunities to succeed (World Bank, 2019).

Improving the quality of education and creating better learning environments for learners in Rwanda is part of a holistic package that includes infrastructure development, among other areas within its range. Rwanda has over the years invested heavily in building, rehabilitating, and upgrading school infrastructure across all corners of the country. Jolly was part of this team and today, we learn that the government's commitment to infrastructure development has had a lot of benefits in how the Rwandan education system works. Rwandan schools have more easily expanded and built new buildings to increase the number of places for students and reduce crowding in classes. This has enabled significantly improved access to education so that more children could attend school as well as receive their schooling. (Ministry of Education, 2020).

Improved learning environment New schools have been constructed or headline focusing on the renovation of classrooms to provide secure and comfortable spaces for students, including appropriate seating arrangements as well as adequate lighting and ventilation to Provide an overall great experience.

Furthermore, infrastructure development is another aspect that reduced budget management officials are working to address: facilities inside schools. This will be in the shape of libraries, laboratories, computer rooms, and sports units. These resources allow students to get involved in many ways in practice learning, research, and extra-curricular activities that only serve to improve their education. Rwanda has also prioritized the integration of technology in schools' infrastructure development by equipping classrooms with digital resources, providing access to computers and the internet, and implementing e-learning initiatives. By embracing technology, Rwanda aims to enhance students' digital literacy and prepare them for the demands of the modern world.

Schools' Infrastructure Development for Chemistry Education on Pupils Learning Outcomes in Chemistry Subject

Better infrastructure development for chemistry education in public secondary day schools can improve pupils' performance. Improving and stocking up public day schools' apartments of chemistry with modern equipment, chemicals as well protective means can give the students practical return for their learning approach to allow an in-depth comprehension of chemical theories data that are helpful and conducive aided by better scores (Gibson, 2019). Classrooms that are thoughtfully designed to allow natural light, ventilation, and seating for comfort. It will help them to stay more focused, and interested and understand chemistry classes better (Kumar, 2018).

The entire library infrastructure on the prevailing model of physical access to books, encyclopedias, and digital libraries would be especially necessary for facilitating learning resources such as textbooks, reference materials, etc. It further recommended that appropriate chemistry books should be combined with easily accessible libraries and online resources to provide students with the necessary opportunity for research and independent learning skills for better education results. (UNESCO 2017)

Health and Environmental Concerns: Schools' built environment needs to be constructed with safety standards in mind because the health of school building occupants is crucial. Chemical storage, safety equipment, and procedures: The more carefully students are taught how to handle chemicals in the laboratory by using correct procedure (from proper disposal of hazardous substances such as acids and mercury) when not experimenting, the better for learning outcomes across a range of chemistry labs. These factors provide insights into a positive relationship between the development of schools' infrastructure and learning outcomes, in chemistry subject however the overall effect can be moderated by other things including low-quality teaching/knowledge teachers have on relevant content they teach that is parallel with the current curriculum as possible to students' characteristics (Asim K. Lushani; Akhter HussainBhat et al., 2017)

Pupils learning outcomes in chemistry subject achieved through schools' infrastructure development for chemistry education

School infrastructure development of public day schools in Rwanda is necessary for fostering positive learning outcomes pupils have chemistry lessons, and the setting or renovation and supply with modern equipment & chemical materials through chemistry labs would generate practical learning opportunities that can provide better understanding among learners towards studied chemical concepts using hands-on activities. This helps to promote critical thinking, problem-solving skills, and a better understanding of chemistry concepts (Mugisha, 2018).

Upgrading libraries and resource centers in public day schoolscan enhance pupils' access to relevant learning materials in chemistry, access to textbooks, reference books, online resources, and scientific journals can support independent learning, research, and a deeper understanding of chemistry concepts (Rutaremwa, 2018). Infrastructure development that includes well-designed and well-maintained classrooms can create a conducive learning environment for pupils studying chemistry. Proper lighting, ventilation, and comfortable seating arrangements can contribute to students' concentration, engagement, and active class participation. These factors can positively impact their learning outcomes (Mugisha, 2018).

Correlation Between schools' infrastructure development for chemistry education in public secondary day schools and pupils' learning outcomes in chemistry subject.

Schools' infrastructure development for chemistry education plays a crucial role in the achievement of desired pupils' learning outcomes in chemistry subjects, as it ensures that chemistry subject is learned better through practical activities to understand the key chemical concepts. By establishing chemistry laboratories with well-equipped materials and access toPractical Learning Opportunities, the use of apparatuses and chemical reagents can improve the pupils' learning outcomes in chemistry subjects in public day schools in Rwanda, The recent studies have shown a positive correlation between schools' infrastructure development in public day schools and pupils' learning outcomes in the chemistry subject. The quality of infrastructure and learning environments can significantly impact pupils learning outcomes in chemistry subject.

Schools' infrastructure development in terms of well-equipped chemistry laboratories, libraries, and learning materials, can provide pupils with valuable resources to enhance their understanding of chemistry. Access to up-to-date textbooks, reference materials, and scientific equipment supports practical learning experiences, promotes independent study, and correlates with improved learning outcomes (Mugisha, 2018).

Infrastructure development that focuses on providing modern and well-equipped chemistry laboratories enables students to engage in hands-on experiments and practical applications of chemical principles. Practical learning experiences have been found to positively correlate with improved understanding, critical thinking skills, and higher academic performance in chemistry (Gibson, 2019).

School infrastructure development that ensures safety measures, proper ventilation, and well-maintained classrooms can create a conducive learning environment. Such an environment fosters concentration, active student engagement, and positive attitudes toward learning chemistry, which in turn correlates with improved learning outcomes (UNESCO, 2016)

Scientific, technological engineering, and mathematics (STEM) are the bedrock of success in Rwanda which has a distinct objective since its government targeted SDGS 4. This study only suggested a correlation of schools' infrastructure development for chemistry education on pupils' learning outcomes in the subject, which is obvious but other factors (teaching quality; school management; student motivation/ situs itself, and socioeconomic) will most likely influence their ultimate contributions to expected "positive" impact indicators.

Theoretical framework

This study is based on the infrastructure theory and Pupils' Learning outcomes –Based Research.

Infrastructure Theory

According to Smith (2024), infrastructure theory is a multidisciplinary field that investigates the socio-technical dimensions of infrastructure systems. It looks into the interactions among physical infrastructure, social practices, institutional frameworks, and power dynamics to gain insights into how infrastructure is developed, operates, and influences societies, economies, and organizations. Infrastructure theory is valuable for assessing the resilience and sustainability of infrastructure systems. Considering long-term consequences and potential challenges enables the evaluation of the infrastructure's capacity to adapt to shifting conditions, endure disruptions, and support sustainable development (Mackenzie, 2019).

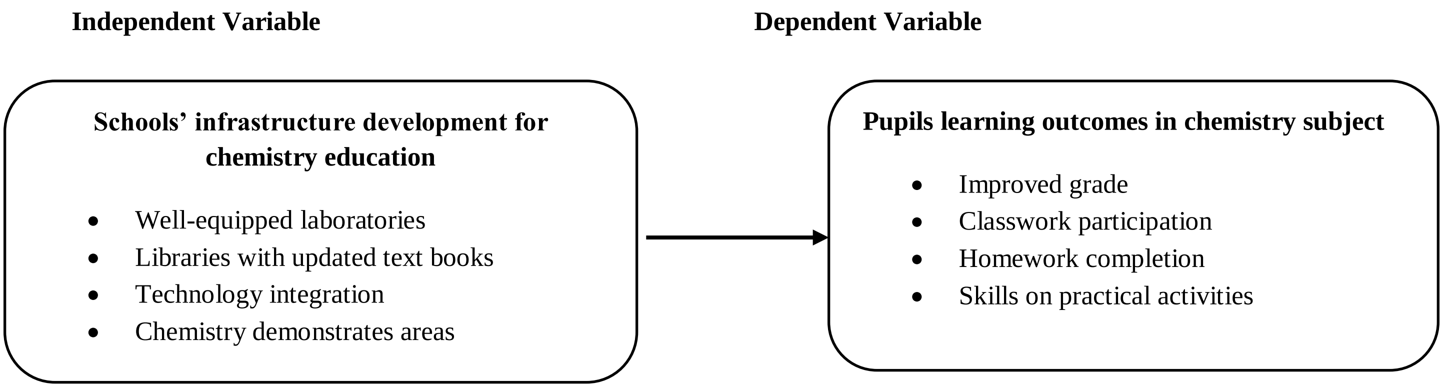
Pupils learning outcomes theory

According to Davis (2024), pupils' The information, abilities, attitudes, and competences that students acquire during their educational experiences are all included in the learning outcomes. This research will concentrate on the learning outcomes of pupils in the chemistry subject, examining the impact of various educational interventions, instructional strategies, and curriculum designs on students' academic performance and overall development.

The study will typically involve data collection related to pupils' learning outcomes in chemistry at public secondary day schools, focusing on improved grades and skills in practical activities, participation in class, and completion of homework. The researcher may utilize a variety of assessment tools, including standardized tests, performance tasks, observations, interviews, and surveys, to collect evidence of pupils' learning outcomes in the chemistry subject.

Conceptual framework

The conceptual framework indicates the interrelationship between the independent variable and the dependent variable.



Source: researcher 2024

Research Methodology:-

Research design

Trochim (2021) defines study design as all of the concepts or strategies that investigators employ in order to address the research questions. The nature of the research topic, the researcher's viewpoint, and the study's objectives all have an impact on the research design selection. A deeper understanding of the effect of infrastructure on student learning outcomes in chemistry teaching in Rwandan secondary schools was achieved by combining quantitative findings and results. Qualitative data helps explain and present quantitative results, while quantitative results provide evidence to support better understanding. Participants were a sample of secondary schools in Rwanda and included secondary and day students, secondary and day teachers, educational supervisors, and leaders in the Rusiro district.The researchers developed surveys and conducted interviews to assess the availability, quality, and accessibility of chemical resources such as pharmaceutical laboratories, consumables, product use, integration, and libraries.

Target population

According to Creswell (2021), the total group of people to whom the researcher hopes to apply the results is known as the target population. This is a reference to the group that is used to create the study sample. In the study on school infrastructure development for chemistry education and student learning outcomes in public secondary schools in Rwanda, the target population is defined as all students in public secondary boarding and day schools, teachers in boarding and day schools, education sector inspectors, and local administrative officials in Rwanda. This group was chosen as the focus of the study because public secondary boarding and day schools in Rwanda are the main providers of chemistry education for the majority of students, and school infrastructure development is a critical factor in supporting effective chemistry teaching and learning. The target population of this study included four local education officers: one local education officer, one local education officer, and two education sector inspectors; 175 teachers from public boarding schools and public day schools; and 483 students from selected public boarding secondary schools and public secondary schools in Rutsiro district, with a total target population of 662.

Sample design

According to Creswell (2021), sampling design refers to the specific strategies and procedures that scientists employ in order to choose a sample from the intended audience. In order to guarantee that the research findings may be used broadly, it is crucial that the sample chosen for the study be representative of the greater target population. In this study on the development of school infrastructure and student learning outcomes for chemistry education in public secondary schools in Rwanda, probability sampling was used as a procedure in which the researcher first identified clusters and then extracted samples from them. Clusters were selected and finally, people from the selected clusters were selected.

Sample Size Determination

This study examined the development of chemistry education infrastructure in schools and the academic performance of students in chemistry courses in public secondary schools in, the research calculated sample size Slovin's formula which is the error parenthesis population will be 249 people.

$n=N/(1+〖N(e)〗^2)$ $n=662/(1+〖662(0.05)〗^2)=249$

Where n is the sample size, N is the population and e is the margin of error.

Through representatives from various groups such as students, district administration officials, and teachers, the sample size was focused on understanding the schools' infrastructure development for chemistry education in public secondary day schools in Rwanda. This method helped in the improvement of effective school infrastructure development due to the involvement of the beneficiaries affected by the scarcity of well-equipped chemistry laboratories.

Table 3.1:- Target Population and Sampled Size.

No	Types of respondents	Target population	Sample Size
1	Government Officials (1 DDE, 1DEO, 2 SEIs)	4	4
2	Teachers from both sampled boarding schools and day schools	175	21
3	Students from both sampled boarding and day schools	483	224
	Total		**249**

Sampling Techniques

The researcher used purposive sampling for district education leaders and simple random sampling for students and teachers in the study on the infrastructure development for chemistry education and the outcomes of learning in chemistry subjects in public secondary day schools in Rwanda. The researcher was able to gather a representative sample of students, instructors from public high boarding and day schools, and district leadership representatives by combining these sampling procedures. These sampling strategies improved the study's findings' generalizability and gave insight into the infrastructure development of chemistry education in schools as well as the learning outcomes of students in chemistry courses in public secondary day schools in Rwanda, particularly in the Rutsiro district.

Research Findings And Discussions:-

Demographic Characteristics of Respondents

In public secondary day schools in Rwanda's Rutsiro District, data on gender profile, age group, educational attainment, and teaching experience were obtained for this study.

Gender of Respondents

When examining the impact of school infrastructure development for chemistry education on students' learning outcomes in chemistry topics in Rwandan public secondary day schools, the gender profile of the responder was crucial.

Table 4.1:- Gender of Respondent.

	Government Officials		**Teachers**		**Students**	
	N	**%**	**N**	**%**	**N**	**%**
Male	2	50.0	14	66.6	106	47.4
Female	2	50.0	7	33.4	118	52.6
Total	**4**	**100.0**	**21**	**100.0**	**224**	**100.0**

Source: Primary Data (2024)

Two (50.0%) of the government officials (1 DDE, 1 DEO, and 2 SEIs) that took part in this study are male, while the remaining two (50.0%) are female, according to the data in 4.1. Of the teachers that took part in this study, 7 (33.4%) were men and 14 (66.6%) were women. Among the student body, 106 (47.4%) are men and 118 (52.6%) are women. Spangaro (2019) discovered that girls who take AP science classes are more likely to excel academically and pursue STEM degrees in college. Gender stereotypes and biases in school infrastructure, such as the design of science classrooms and laboratories, may contribute to the gender gap in STEM education. Research has found that girls have less access to science resources, such as laboratory equipment and technology, and have fewer female STEM teachers and mentors.

Age of Respondents

It is crucial to provide details on the respondents' age group, as shown in Table 4.2.

Table 4.2:- Age Group of Respondents.

Age of Respondents	Frequency	Percentage
21-25 Years	33	13.25
26-30 Years	61	24.49
31-35 Years	92	36.94
36-40 Years	48	19.277
41 years and above	15	6.024
Total	**249**	**100.0**

Source: Primary Data (2024)

Table 4.2 shows that 13.25% of respondents are between the ages of 21 and 25; 24.49% are between the ages of 26 and 30; 36.94% of respondents who participated in the study were between the ages of 31 and 35; 19.277% are between the ages of 36 and 40; and 6.6% of respondents who participated in the study were older than 41. This suggests that the investigation's age characteristics were balanced. The results of the study did not conflict with Robinson's (2018) findings. These studies discovered that respondents' ages can influence how school infrastructure is planned and chemistry is taught, resulting in varied learning outcomes for students of different ages.

Education Qualification of Respondents

Evaluating the greatest degree of qualification obtained by respondents from basic secondary, advanced secondary, bachelor's, master's, and doctorate levels was necessary. Education level can influence the expertise and knowledge of respondents in their respective fields. Respondents with higher levels of education are generally more knowledgeable and experienced in their field, which can lead to more comprehensive and well-researched studies. They have had more chances to research and get knowledge from professionals in their industry, and they have probably had more experience conducting research and publishing their findings.

Table 4.3:- Education Attainment.

	Government Officials		Teachers		Students	
	N	**%**	-	-	**N**	**%**
Primary Level	-	-	-	-	149	100.0
Ordinary Level	-	-	-	-	-	-
Advanced Level	-	-	-	-	-	-
Bachelors	3	75	21	100.0	3	100.0
Masters	1	25	-	-	-	-
PhD	-	-	-	-	0	0
Total	4	**100.0**	**21**	**100.0**	**249**	**100.0**

Source: Primary Data (2024)

Information presented in Table 4.3, 75.5% of Government Officials (1 DDE, 1DEO,2 SEIs) were studying for a bachelor’s degree, while 25.7 % hold master’s degrees. For the case of Teachers 100.0 bachelor’s degree. Finally, 100 % hold the primary level certificate. (Mueller, 2017) Students with higher levels of education may require more modern laboratory equipment and technology, while students with lesser levels may need more hands-on, interactive learning experiences. Additionally, children with greater levels of education may have different learning styles and preferences than students with lower levels of education, which can alter how chemistry is taught and how school infrastructure is designed.

Distribution by Work Experience

Research participants' learning/teaching experiences are divided into four categories: less than a year, one to three years, four to six years, and more than six years. There is data in Table 4.4.

Table 4.4:- Work Experience.

	Government Officials		Teachers	
Years	**N**	**%**	**N**	**%**

<5	-	-	0	0
5 <10	1	25.0	11	52.3
>10	3	75.0	10	47.6
Total	**4**	**100.0**	**21**	**100.0**

Source: Primary Data (2024)

Table 4.4 displays data indicating that 25.0% of government officials had experience ranging from five to ten years, while 75.0.4% had experience exceeding ten years. 52.3% of teachers have worked for five to ten years, while 47.6% of teachers have more than ten years of experience.

Presentation of Findings

Data collected under the study's dependent variables and research goals are analyzed. 249 individuals provided qualitative and quantitative data for the research. The study identified the infrastructure development for chemistry education in Rwandan public secondary day schools, examined the impact of this infrastructure development on students' learning outcomes in chemistry subjects, and established a causal relationship between the infrastructure development for chemistry education and students' learning outcomes in chemistry subjects in Rwandan public secondary day schools.

The schools' infrastructure development for chemistry education in public secondary day schools in Rwanda

The study evaluated the infrastructural development of Rwandan public secondary day schools for the teaching of chemistry. The responses of the participants to the following statements are displayed in the accompanying tables. The schools 'infrastructure development for chemistry education in public secondary day schools is well developed and used effectively, the necessary infrastructure development for chemistry education and facilities are available for learning and teaching chemistry subjects in public secondary day schools and Teachers of chemistry in public secondary day schools are adequately trained for using laboratory equipment in performing scientific experiment in chemistry subject

Table 4.5:- Teachers' Perception of the Schools' infrastructure development for chemistry education.

Statements	**Strongly Disagree**		**Disagree**		**Neutral**		**Agree**		**Strongly Agree**		**Mean**	**Std**
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		
The schools 'infrastructure development for chemistry education in public secondary day schools is well developed and used effectively	0	0.0	0	0.0	1	4.8	1	4.8	19	90.5	1.67	1.278
The necessary infrastructure development for chemistry education and facilities are available for learning and teaching chemistry subjects in public secondary day schools	0	0.0	1	4.8	1	4.8	3	14.3	16	76.2	1.14	.478
Teachers of chemistry in public secondary day schools are adequately trained for using laboratory equipment in performing scientific experiments in chemistry subject	0	0.0	1	4.8	2	9.5	2	9.5	16	76.2	1.38	.805

Source: Primary Data (2024)

The findings in Table 4.5 demonstrate how educators feel about the infrastructure development for chemistry teaching in Rwandan public secondary schools. Consequently, 19 (90.5%) educators highly concurred with 1 (4.8%) that the schools 'infrastructure development for chemistry education in public secondary schools is well developed and used effectively. 16 (76.2%) teachers strongly agreed, and 3 (14.3%) said that the necessary infrastructure development for chemistry education and facilities are available for learning and teaching chemistry subjects in public secondary schools. 16 (76.2%) teachers strongly agreed, and 2 (9.5%) said that teachers of chemistry in public secondary schools are adequately trained to use laboratory equipment to perform scientific experiments in chemistry subjects. Kimani (2020) found that using teaching materials improves student performance compared to those who do not use them. Inadequate learning materials and equipment in schools contribute significantly to poor chemistry performance. Poorly equipped laboratories provide insufficient learning opportunities, leading to poor academic performance. Teachers should be able to discover and create easy instructional aids in their environment. Some teachers avoid employing instructional aids, which might significantly impact student performance.

Table 4.6:- Students Perception towards the schools' infrastructure development for chemistry education.

Statements	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	Std
	N	%	N	%	N	%	N	%	N	%		
The schools 'infrastructure development for chemistry education in public secondary day schools is well developed and used effectively	0	0.0	10	4.5	20	8.9	20	8.9	174	77.7	1.63	1.221
The necessary infrastructure development for chemistry education and facilities are available for learning and teaching chemistry subjects in public secondary day schools	10	4.5	11	4.9	12	5.4	20	8.9	171	76.3	1.60	1.190
Teachers of chemistry in public secondary day schools are adequately trained for using laboratory equipment in performing scientific experiments in chemistry subject	0	0.0	11	4.9	35	15.6	40	17.9	138	61.6	1.79	1.158

Source: Primary Data (2024)

The results in Table 4.6 evidenced the students' perceptions of the schools' infrastructure development for chemistry education. Accordingly, 174 (77.2%) students strongly agreed and 20 (8.9%) agreed that the schools' infrastructure development for chemistry education in public secondary day schools is well developed and used effectively, 171 (76.3%) students strongly agreed and 20 (8.9%) agreed that the necessary infrastructure development for chemistry education and facilities are available for learning and teaching chemistry subjects in public secondary day schools, and 138 (61.6%) students strongly agreed and 40 (17.8%) agreed that teachers of chemistry in public secondary day schools are adequately trained for using laboratory equipment in performing scientific experiments in chemistry subjects. The study found that 174 students (77.2%) strongly agreed that public secondary day schools have a well-developed infrastructure for chemistry education, with facilities available for learning and teaching. Additionally, 138 (61.6%) students agreed that teachers are adequately trained to use laboratory equipment for scientific experiments. Naylor (2017) found that teachers often lack the necessary resources, including textbooks, lab equipment, and classroom supplies. According to Thabo Fako (2019), education has increased and expanded, but resources have not improved. Teachers experience increased stress due to limited resources. When teachers are stressed, it affects students, leading to failure. Blind learners can excel in science topics with proper adaptations and modifications in labs and libraries. Lack of these leads to poor academic achievement for students with blindness in Chemistry.

The pupils' learning outcomes in chemistry subject that are due to the schools' infrastructure development for chemistry education in public secondary day schools in Rwanda

This study analyzed the extent of the pupils' learning outcomes in chemistry subjects that are due to the schools' infrastructure development for chemistry education in public secondary day schools in Rwanda.

Table 4.7:- Students' perception of their learning outcomes in chemistry subject.

Statements	**Strongly Disagree**		**Disagree**		**Neutral**		**Agree**		**Strongly Agree**		**Mean**	Std
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		
The pupils' learning outcomes in chemistry subjects in your school have improved the school's infrastructure development for chemistry education in terms of laboratories and equipment	0	0.0	10	4.5	39	17.4	40	17.9	135	60.3	1.62	.196
The availability of effective school infrastructure development for chemistry education has positively affected the pupils' focus on chemistry concepts	9	4.0	11	4.9	16	7.1	16	7.1	168	75.0	1.60	1.167
The development of schools' infrastructure development for chemistry education has increased pupil's access to educational resources and materials in chemistry subject	5	1.4	9	4.0	19	8.5	20	8.9	171	76.3	1.80	1.152

Source: Primary Data (2024)

According to the information depicted in Table 4.7, accordingly, 135 (60.3) students strongly agreed and 17.9% agreed that The pupils' learning outcomes in chemistry subject in your school have improved by the schools' infrastructure development for chemistry education in terms of laboratories and equipment; 168(75.0) students strongly agreed and 7.1% agreed that The availability of effective schools' infrastructure development for chemistry education has positively affected the pupils focus in chemistry concepts; 171 (76.3) students strongly agreed that The development of schools' infrastructure development for chemistry education has increased pupils access to educational resources and materials in chemistry subject with 8.9 % who agreed with this statements. Sindikubwabo (2022) discovered that 71.0% of senior two pupils in the Rutsiro district do poorly in chemistry. Poor performance is influenced by less activity-based teaching strategies, bad attitudes towards chemistry, a lack of resources, and a low familial background. The findings indicated that teachers, parents, and school administrators must be mobilized to encourage kids to enjoy chemistry as a basic subject. To improve teaching and learning, decision-makers should provide suitable facilities such as laboratories, libraries, smart classrooms, and internet connectivity.

Table 4.8:- Teachers' Perception towards the students' learning outcomes in the chemistry subject.

Statements	**Strongly Disagree**		**Disagree**		**Neutral**		**Agree**		**Strongly Agree**		**Mean**	Std
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		
The pupils' learning outcomes in chemistry subjects in your school have improved the school's infrastructure development for chemistry education in terms of laboratories and equipment	1	4.8	2	9.5	2	9.5	2	9.5	14	66.7	1.76	1.261
The availability of effective school infrastructure	0	0.0	1	4.8	1	4.8	2	9.5	17	81.0	1.60	1.209

development for chemistry education has positively affected the pupils' focus on chemistry concepts											
The development of schools' infrastructure development for chemistry education has increased pupil's access to educational resources and materials in chemistry subject	0	0.0	1	4.8	3	14.3	4	19.0	13	61.9	1.81	1.209

Source: Primary Data (2024)

Results presented in Table 4.8 show that 14 (66.7) teachers strongly agreed and 9.5% agreed that The pupils learning outcomes in chemistry subject in your school have improved the schools' infrastructure development for chemistry education in terms of laboratories and equipment; 17(81.0) students strongly agreed and 9.5 % agreed that The availability of effective schools' infrastructure development for chemistry education has positively affected the pupils focus in chemistry concepts; 13 (61.9) students strongly agreed that The development of schools' infrastructure development for chemistry education has increased pupils access to educational resources and materials in chemistry subject with 19.0 % who agreed with this statements. Levendosky (2019) analyzed the impact of smart classrooms on chemistry learners' performance. Results showed a significant difference between those taught through and without smart classrooms. The study suggests increasing smart classrooms across the country to improve teaching and learning processes. It also suggests focusing on other chemistry units and involving smart classrooms in educational activities.

The relationship between the schools' infrastructure development for chemistry education and pupils' learning outcomes in chemistry subjects in public secondary day schools in Rwanda

Table 4.9:- Correlation betweenthe schools' infrastructure development for chemistry education and pupil's learning outcomes in chemistry subjects in public secondary day schools in Rwanda.

		Well-equipped laboratories	Libraries with updated textbooks	Technology integration	Chemistry demonstrations areas	Improved grade	Classwork participation	Homework completion	Skills in practical activities
Well-equipped laboratories	Pearson Correlation	1	.317**	.163*	.115	.197**	.796**	.736**	.770**
	Sig. (2-tailed)		.000	.029	.125	.008	.000	.000	.000
	N	249	249	249	249	249	249	249	249
Libraries with updated textbooks	Pearson Correlation	.317**	1	.596**	.591**	.263**	.272**	.197**	.243**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.008	.001
	N	249	249	249	249	249	249	249	249
Technology integration	Pearson Correlation	.163*	.596**	1	.495**	.156*	.211**	.182*	.118
	Sig. (2-tailed)	.029	.000		.000	.037	.005	.015	.116
	N	249	249	249	249	249	249	249	249
Chemistry demonstrations areas	Pearson Correlation	.115	.591**	.495**	1	.217**	.367**	.254**	.224**
	Sig. (2-tailed)	.125	.000	.000		.003	.000	.001	.002

	N	249	249	249	249	249	249	249	249
Improved grade	Pearson Correlation	.197**	.263**	.156*	.217**	1	.205**	.357**	.339**
	Sig. (2-tailed)	.008	.000	.037	.003		.006	.000	.000
	N	249	249	249	249	249	249	249	249
Classwork participation	Pearson Correlation	.796**	.272**	.211**	.367**	.205**	1	.766**	.700**
	Sig. (2-tailed)	.000	.000	.005	.000	.006		.000	.000
	N	249	249	249	249	249	249	249	249
Homework completion	Pearson Correlation	.736**	.197**	.182*	.254**	.357**	.766**	1	.795**
	Sig. (2-tailed)	.000	.008	.015	.001	.000	.000		.000
	N	249	249	249	249	249	249	249	249
Skills in practical activities	Pearson Correlation	.770**	.243**	.118	.224**	.339**	.700**	.795**	1
	Sig. (2-tailed)	.000	.001	.116	.002	.000	.000	.000	
	N	249	249	249	249	249	249	249	249

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Source: Primary Data (2024)

The data demonstrated in Table 4.7 showed an association between research variables. Improved grade: there is a statistical association between improved grade and well-equipped laboratories (r =.197** p-value = 0.008), improved grade and libraries with updated textbooks (r =.263** p-value = 0.000), improved grade and technology integration (r =.156* p-value = 0.037), as well as improved grade and chemistry demonstration areas (r =.217** p-value = 0.003). Since the p-value was 0.5, these connections were positively related.

Classwork participation There is a statistically significant link between classwork participation and well-equipped laboratories (r =.796**, p-value = 0.000). Classwork participation and libraries with updated textbooks (r =.272**, p-value = 0.000); classwork participation and technology integration (r =.211**, p-value = 0.005); and classwork participation and chemistry demonstration areas (p-value = 0.000, r =.367**). Since the p-value was 0.5, these connections were positively related. Because the p-value was greater than 0.05, this association is negligible.

For skills on practical activities, there is a significant relationship between skills on practical activities, a statistically significant association between skills on practical activities and well-equipped laboratories (r =.770** p-value = 0.000), skills on practical activities and libraries with updated textbooks (r =.243** p-value = 0.001), and an insignificant association between skills on practical activities and technology integration (r =.118, p-value = 0.116), along with classwork participation and chemistry demonstration areas (p-value = 0.002, r =.224**). Since the p-value was 0.5, these connections were positively related.

Therefore, the study found a significant association between improved grades, classwork participation, well-equipped laboratories, updated textbooks, technology integration, and chemistry demonstration areas. Classwork participation was positively related to well-equipped laboratories, updated textbooks, technology integration, and chemistry demonstration areas. Skills in practical activities were positively related to well-equipped laboratories, updated textbooks, and chemistry demonstration areas. However, there was no significant association between skills in practical activities and technology integration or classwork participation. This research is related to the work of Spangaro (2019), who indicates that school infrastructure is critical for effective teaching and learning in secondary education, intending to increase student attendance, motivate teachers, and improve academic performance. It consists of classrooms, laboratories, halls, open fields, sports equipment, dorms, and restrooms. To attain national goals, the Kenyan government must focus on improving school infrastructure. The purpose of this study was to examine how school infrastructure affects excellent education in Kajiado County's public secondary schools. The findings revealed that increased academic attainment is linked to more appropriate classrooms, abundant library space, adequate science laboratories, adequate water and sanitation facilities, and adequate engagement in extracurricular activities.

Table 4.10:- Regression Coefficients between independent variables and Homework completion.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.013	.122		.106	.916
	Well-equipped laboratories	.982	.064	.774	15.346	.000
	Libraries with updated textbooks	-.332	.089	-.256	-3.738	.000
	Technology integration	.095	.084	.069	1.128	.261
	Chemistry demonstrations areas	.300	.065	.282	4.641	.000

a. Dependent Variable: Homework completion

Primary Data as a Source (2024)

Table 4.8 provided evidence that regression coefficients indicated Homework completion was positively significant to Well-equipped laboratories (B=.774, p-value=.000), Results show negative significance between Homework completion and Libraries with updated textbooks (B=-.256, p-value=.000), Homework completion was positive significant to Chemistry demonstrations areas (B=.282, p-value=.000) finally Technology integration was statistically insignificant affecting Homework completion (B=.069, p-value=.261). The National Center for Education Statistics (2021) found that students who completed homework assignments regularly in mathematics and reading scored higher on standardized tests than those who did not complete homework assignments regularly. Another study by the Journal of Educational Research and Review found that homework completion was positively correlated with student achievement in science, mathematics, and language arts.

Table 4.11:- Regression Coefficients between independent variables and Skills on practical activities.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.100	.114		.875	.383
	Well-equipped laboratories	.959	.060	.787	16.019	.000
	Libraries with updated textbooks	-.128	.083	-.103	-1.544	.124
	Technology integration	-.080	.078	-.060	-1.017	.311
	Chemistry demonstrations areas	.229	.060	.225	3.795	.000

a. Dependent Variable: Skills in practical activities

Source: Primary Data (2024)

Data presented in Table 4.9 evidenced that regression coefficients indicated Skills on Practical Activities was positively significant to Well-equipped laboratories (B =.787, p-value =.000), results show a negative insignificant relationship between Skills on Practical Activities and Libraries with updated textbooks (B =.225, p-value =.000), Skills on practical activities was positively significant to Chemistry demonstrations areas (B =.282, p-value =.000), and finally Technology integration was statistically insignificant in affecting Skills on practical activities (B =-.060, p-value =.311). According to Sarah (2019), the skills required for practical. Activities in chemistry can significantly influence student performance in the subject. Practical activities in chemistry allow students to apply theoretical knowledge to real-world situations, which can help them better understand and retain the material.

Table 4.12:- Regression Coefficients between independent variables and Improved grade.

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.685	.154		4.459	.000
	Well-equipped laboratories	.218	.080	.203	2.711	.007
	Libraries with updated textbooks	.272	.111	.248	2.454	.015
	Technology integration	.051	.112	.744	.458	.000
	Chemistry demonstrations areas	-.077	.129	.361	-.593	.000

a. Dependent Variable: Improved grade

Source: Primary Data (2024)

Table 4.8 provided evidence that regression coefficients indicated Improved grade was positively significant to Well-equipped laboratories (B =.203, p-value =.007), results show a negative insignificant relationship between Improved grade and Libraries with updated textbooks (B =.248, p-value =.015), Improved grade was positively significant to Chemistry demonstrations areas (B =.361, p-value =.000), and finally Technology integration was positively statistically significant in affecting Improved grade (B =.744, p-value =.000). Martha (2018) found that smart classroom components like projectors, computers, interactive whiteboards, and video simulations motivate students to teach and learn chemistry. Results from 101 senior-five students showed a positive effect on performance in both the control and experimental groups.

Table 4.13:- Regression Coefficients between independent variables and Exams and tests.

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.095	.092		-1.035	.302
	Well-equipped laboratories	.973	.048	.822	20.239	.000
	Libraries with updated textbooks	-.290	.067	-.240	-4.360	.000
	Technology integration	.025	.063	.019	.394	.024
	Chemistry demonstrations areas	.402	.049	.406	8.282	.000

a. Dependent Variable: Classwork participation

Source: Primary Data (2024)

Table 4.11's data demonstrated that regression coefficients indicated Classwork participation was positively significant to Well-equipped laboratories (B =.203, p-value =.007), results show a negative insignificant relationship between Classwork participation and Libraries with updated textbooks (B =.248, p-value =.015), Classwork participation was positively significant to Chemistry demonstrations areas (B =.361, p-value =.000), and finally Technology integration was positively statistically significant in affecting Classwork participation (B =.744, p-value =.000).According to a Rwandan study, group work-related activities are given priority by chemistry teachers (Byusa, 2020). To meet the expectations of the Competence-Based Curriculum (CBC) (REB, 2015), teachers must teach chemistry and develop other expected learning outcomes related to values and attitudes that are associated with the lesson taught. These instructional strategies must be implemented in the classroom to maximize student motivation for daily chemistry activities.

Conclusions and Recommendations:-

Conclusions:-

By considering the findings from this present research and the research objectives, the study gives commonly, the indicators of the schools' infrastructure development for chemistry education in Rutsiro district, Rwanda, which are well-equipped laboratories, Libraries with updated textbooks, Technology integration and Chemistry demonstrates areas.

To the first objective, results indicate 95.3% either strongly agreed or agreed that the schools 'infrastructure development for chemistry education in public secondary schools is well developed and used effectively; either strongly agreed or agreed that the necessary infrastructure development for chemistry education and facilities are available for learning and teaching chemistry subjects in public secondary schools; and 85.7% either strongly agreed or agreed that teachers of chemistry in public secondary schools are adequately trained for using laboratory equipment in performing scientific experiments in chemistry subjects.

To the second objective, the study indicates that either strongly agreed or agreed that the pupils' learning outcomes in chemistry subjects in your school have improved because of the schools' infrastructure development for chemistry education in terms of laboratories and equipment; strongly agreed or agreed that the availability of effective schools' infrastructure development for chemistry education has positively affected the pupils focus on chemistry concepts; and 85.2% either strongly agreed or agreed that the development of schools' infrastructure development for chemistry education has increased pupils access to educational resources and materials in chemistry subject. The results of the third objective, schools' infrastructure development for chemistry education, have a positive significance for pupils' learning outcomes in chemistry since the p-value is less than 0.05 in the Rutsiro district.

Recommendations:-

According to the results in chapter four, the development of chemistry education infrastructure in Rwanda is crucial for students' learning outcomes.

Recommendations to Government Organizations (NGOs) include improving collaboration with the government of Rwanda and education stakeholders to support educational facilities, providing resources and training for teachers on the use of laboratories and their equipment to enhance pupils' learning outcomes in chemistry subjects in public secondary day schools in Rwanda.

Recommendations to the Ministry of Education include establishing well-equipped laboratories with modern equipment, ensuring safety measures, designating classrooms for chemistry education, stocking the school library with relevant resources, building a central science laboratory, providing teacher training, collaborating with educational authorities to develop a curriculum aligned with international standards, and establishing a system for assessing students' progress in chemistry. These measures will help improve the country's chemistry education infrastructure and support students in achieving better learning outcomes.

Recommendations to education policymakers should employ equity in the distribution of all required education resources in all areas of the country in terms of developed education infrastructure and provision of qualified teachers specifically in remote areas to improve the pupils' learning outcomes in chemistry subject in Rwanda.

Suggestion for Further Study:-

The researcher suggested that the next study should focus on addressing gender disparities in chemistry education strategies to promote gender equity in public secondary schools.

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