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Mathematics Laboratory Usage and Development of Students' Mathematics Skills in Public Secondary Schools in Rwanda: A Case of Selected Schools in Musanze District

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ABSTRACT: This study investigated the effect of Mathematics laboratory usage on development of students' Mathematics skills in public secondary schools in Musanze District, Rwanda. This study blueprinted the specific objective: to explore the effect of Mathematics laboratory usage components on self-reported measures in selected secondary schools. A total of 2663 students and 16 Mathematics teachers were selected and used to calculate a sample size of 348 students and 16 Mathematics teachers, which represented the majority of the population. The research used a mixed-methods approach, combining quantitative data from surveys with qualitative insights from interviews and classroom observations. The study assessed four key components of Mathematics laboratory usage: frequency of lab use, types of lab activities, quality of lab resources and teacher training and support. These components were analyzed in relation to the measure of Mathematics skills development unto self-reported measures. Quantitative findings revealed positive correlations between Mathematics laboratory usage and skills development across self-reported measures. Regression analyses showed that laboratory usage components collectively explained 23.5% in self-reported measures. Qualitative data from teacher interviews highlighted the importance of diverse, hands-on activities in fostering critical thinking and real-world application of mathematical concepts. Classroom observations revealed stark differences between day and boarding schools in terms of student engagement, confidence and resource availability, underscoring the impact of well-equipped laboratories on learning outcomes. The study recommends that schools enhance curriculum integration of lab activities, invest in quality resources and support continuous teacher training. Teachers should use engaging lab activities to reinforce theory and promote active learning, while students are encouraged to participate actively and seek support when needed. These findings highlight the potential of Mathematics labs to improve learning outcomes in Rwandan secondary schools, with implications for education policy and practice nationally and internationally.

I. INTRODUCTION

A solid foundation in Mathematics is vital for careers in fields like engineering, finance, and data analysis. In developed nations, this competency underpins economic success, fueling opportunities in high-demand industries and contributing to national innovation and prosperity (Filgona & State, 2020). Mathematics education’s importance extends beyond academics, equipping individuals with practical problem-solving skills that are essential for navigating complex challenges in modern society (Zrudlo, 2024).

In developing regions, Mathematics education plays a crucial role by providing individuals with critical numeracy and problem-solving skills, which enhance daily decision-making and professional competence. For example, Mathematics aids in sustainable economic development, supporting tasks like financial planning and investment analysis in sectors such as agriculture and infrastructure (Jayanthi, 2019). Furthermore, Mathematics fosters technological skills, bridging the digital divide in these regions, as seen in initiatives that promote digital literacy (Umugiraneza et al., 2017).

Mathematics laboratories have evolved significantly in developed countries, emphasizing hands-on activities and technology, experiential learning. Early advocates like John Dewey championed the idea that students should actively engage with concepts rather than passively receive information, leading to the integration of laboratory methods in the 20th century (Aceska, 2016; Zrudlo, 2024). Modern laboratories utilize technology, integrating real-world applications and inquiry-based learning approaches to build mathematical reasoning, which enhances student engagement and understanding (Baharin et al., 2018; Abdurrahman et al., 2021).

In developing nations, Mathematics laboratories emphasize community involvement and cultural relevance. Programs like Brazil's Mathematics Circles and Kenya's Mathematicians in the Middle have fostered collaborative learning and local engagement, helping to bridge educational gaps in disadvantaged areas (Sujeewa et al., 2021; Kunwar, 2020). Many of these laboratories also incorporate technology, as in South Africa's Mathematical Literacy Project, which uses graphing calculators and software to enable deeper exploration of mathematical concepts (Barakabitze et al., 2019).

In Rwanda, educational reforms have positioned Mathematics as essential to national development, though challenges like resource limitations and rural access disparities persist (Vuong et al., 2019; Rapoport & Berta, 2019). While initiatives such as the Rwanda Basic Education Board's "Science and Mathematics Centers" provide resources, full-scale Mathematics labs remain scarce, contributing to students' perception of Mathematics as abstract (Nungu et al., 2023; Nsengimana, 2021). However, the government's focus on STEM education and potential for integrating technology in labs could transform Mathematics learning, making it more practical and accessible (Scholar, 2021). This study proposes that further research on lab usage and its effects on student development will guide effective teaching strategies and resource allocation in Rwanda. Mathematics laboratories in Rwanda present both challenges and opportunities in enhancing Mathematics education. There are key challenges and opportunities associated with Mathematics laboratories in Rwanda: it faces challenges in terms of limited resources for establishing and maintaining Mathematics laboratories. This includes but is not limited to lack of funding, access to appropriate technology and availability of manipulatives and materials. Mathematics laboratories involve skilled and trained teachers who can effectively use the resources and techniques available (Nungu et al., 2023). However, a lack of teacher training and professional development opportunities in Rwanda hinders the effective implementation of Mathematics laboratories.

Additionally, in some regions of Rwanda, there are limited infrastructure and internet connectivity, they present challenges in accessing technology-based Mathematics laboratories (Scholar, 2021).

In Musanze District, there are two related problems: students face difficulties in developing their Mathematics skills and Mathematics laboratories are not utilized enough, they cause poor performance in assessments and a lack of confidence in real-life Mathematics practices. These intertwined issues affect negatively the students' academic performance and future opportunities. Poor Mathematics performance can moderate students' chances of pursuing STEM-related fields, perpetuating socioeconomic disparities (Ohei, 2023). Weak problem-solving and critical thinking skills can hinder future career prospects in a data-driven economy (Ezinwanyi, 2020). Negative attitudes towards Mathematics can limit personal growth and societal progress towards innovation and development (Makarova et al., 2019). This study aims to investigate how the use of Mathematics laboratories influences skill development among students in selected public secondary schools in Musanze District, Rwanda.

1.1 Statement of the Problem

Since the 1994 Tutsi genocide, Rwanda's education system has focused on universal access and quality, emphasizing science and technology (Education, 2023). While progress has been substantial, challenges remain in enhancing Mathematics education; national and international assessments indicate Rwandan students lagging behind regional and global standards (Vuong et al., 2019). To address these issues, Rwanda Basic Education Board (REB) introduced a Competency-Based Curriculum and initiatives like "One Laptop per Child." However, barriers such as dependance on rote learning, teacher shortages, and limited training in active learning approaches continue to impact their effectiveness (Fidele et al., 2019). Mathematics laboratories offer a promising solution by promoting active learning and practical applications, though they are underutilized and require more investment to maximize their impact (Nsengimana, 2021).

In Rwanda, only a few schools have Mathematics labs, and resource shortages and inadequate upkeep limit their effectiveness (Ukobizaba et al., 2021). Teachers often lack the necessary training to integrate lab activities into the curriculum, leading to underuse and misconceptions about their purpose (Sibomana et al., 2021; Bainomugisha et al., 2023). This contributes to students' difficulties in developing strong Mathematics skills, which affects their performance, confidence, and prospects in STEM careers (Ohei, 2023).

Research on Mathematics education in Rwanda has not thoroughly investigated lab usage, creating a gap in understanding. Addressing these challenges in Musanze District secondary schools is essential for improving learning quality and skill development. This study aims to fill this gap by examining both teachers' and students' views on Mathematics labs and analyzing how lab use affects skill development and academic achievement in Musanze District.

1.2 Study Objectives

The general objective of this study was to determine the effect of Mathematics laboratory usage on students' Mathematics skills development in public secondary schools in Musanze District, Rwanda. Specifically, the study intends to:

i. Explore the effect of Mathematics laboratory usage components on self-reported measures in selected secondary schools in Musanze District.

1.3 Research Question

This study aims to address the following question:

i. How do Mathematics laboratory usage components affect self-reported measures in selected secondary schools in Musanze District?

II. LITERATURE REVIEW

2.1 Theoretical Review

A theoretical review emphasizes conceptual frameworks rather than practical applications. This study's foundation relies on constructivist educational theories, which focus on learners actively building knowledge through experiences and social interactions. Constructivism, as highlighted by Zaccaro et al. (2015), posits that students develop understanding by engaging with content, linking new information to existing knowledge, and collaboratively making sense of material through inquiry and problem-solving. Breuleux (2015) reinforces that students' prior knowledge is crucial for learning new concepts, while Baker et al. (2023) underscore the importance of relating Mathematics to real-world contexts to deepen understanding.

Active learning, closely tied to constructivism, emphasizes hands-on exploration, fostering curiosity and a deeper appreciation for Mathematics (Jeong, 2020). Schwarts et al. (2023) note that constructivism advocates for engaging students actively with concepts, allowing them to better grasp mathematical principles through exploration and practical application. This approach, according to Morgan (2021), also enhances collaborative learning, where social interaction and communication are vital for students to develop and share mathematical knowledge, as well as critical thinking skills (Slavin, 2018).

Experiential learning builds on these principles by involving students in activities and projects that connect mathematical concepts to real-world situations (Baker et al., 2023). Through exploration and experimentation, students are encouraged to reflect on their experiences, link them to prior knowledge, and draw meaningful insights. Kunwar (2020) further notes that collaborative tasks enable students to learn from each other's perspectives, fostering communication and teamwork. Experiential learning activities thus make Mathematics relevant by embedding it in authentic contexts, supporting both understanding and skill development (Vuong et al., 2019).

Interactive methods such as simulations and educational games enhance engagement and bring abstract concepts to life (Jeong, 2020). These tools allow students to experience practical applications of Mathematics, which are crucial for bridging abstract and real-world contexts, as emphasized by Jones and Tiller (2017). Field trips, guest speakers, and experiential exhibits, as suggested by Kunwar (2020), offer students hands-on connections to professional applications of Mathematics. Constructivist and experiential learning theories emphasize active student engagement and practical relevance, while cognitive theories support skill development approaches (Baker et al., 2023; Jean de Dieu et al., 2022). Effective technology integration through Mathematics laboratories fosters active learning, collaboration, and critical thinking, highlighting the need for ongoing professional development and equitable access (Jeong, 2020).

Mostly, a constructivist and experiential approach foster active participation, collaboration and problem-solving, creating a dynamic, learner-centered environment that strengthens students' appreciation and critical thinking skills in Mathematics.

2.2 Empirical Review

Strong Mathematics skills are essential for individual growth and societal progress, fostering analytical thinking, problem-solving, and logical reasoning (Filgona & State, 2020). These skills support cognitive development, enhance financial literacy, and are critical for careers in high-demand STEM fields, fueling innovation and economic growth (U.S. Department of Labor, 2023). Despite their significance, Mathematics education faces obstacles, including ineffective teaching methods and insufficient resources, which could be mitigated through active learning, technology integration, and enhanced teacher training (Akkus, 2016). Developing these competencies is crucial for informed decision-making, resilience, and meaningful societal contributions (Kunwar, 2020).

Mathematics laboratories are crucial for enriching student learning by providing hands-on, experiential activities that simplify complex concepts and make abstract ideas more accessible. Such laboratories promote active participation, collaborative learning, and critical thinking, helping reduce Math anxiety and boost confidence among learners (Charles-Ogan et al., 2016; Slavin, 2018). Integrating technology in these labs further enhances learning by preparing students for data-driven fields and enabling them to visualize complex ideas (Nungu et al., 2023). By supporting diverse learning styles and linking Mathematics to real-world applications, these labs create a dynamic and engaging learning environment that strengthens conceptual understanding and student confidence (Baker et al., 2023).

Challenges to quality Mathematics education include shortage of adequate infrastructure, teacher training deficits, outdated curricula, and limited resources (Morgan, 2021). Addressing these issues requires infrastructure investment, professional development for educators, and bridging curriculum gaps with national standards. Additionally, promoting student engagement, improving resource access and supporting culturally responsive teaching are crucial (Kunwar, 2020).

Empirical studies demonstrate the effectiveness of Mathematics laboratories in enhancing practical skills and critical thinking through hands-on activities and technology (To & Future, 2020). Well-equipped labs enable students to apply theoretical knowledge to real-world scenarios, improving participation and academic performance despite obstacles like cost and training needs (Bilican & Senler, 2021). For example, programs such as Ghana's "Mathematics in a Box," South Africa's Numeracy Lab Project, and Ethiopia's "Mathematics on the Move" have shown that Math labs, equipped with manipulatives and local materials, improve problem-solving skills and student engagement (Agyei et al., 2018; Kuhl, 2021; Delorme, 2016). Success in these initiatives hinges on context-specific activities, continuous teacher training and collaboration with stakeholders to ensure sustainability (Barakabitze et al., 2019; Vuong et al., 2019).

III. RESEARCH METHODOLOGY

This study adopted a mixed-methods approach to gather both quantitative and qualitative data, aiming to explore the impact of Mathematics laboratory usage on skill development among students in Musanze secondary schools. Using Slovin's formula (2010), referenced in Lohr (2021), a sample size of 364 respondents was determined, including 348 Mathematics students randomly selected from a population of 2,663 and 16 Mathematics teachers, with the total population being 2,679. Data collection methods included surveys, interviews and observations to capture a detailed picture of Mathematics education practices and their effects on student outcomes. Quantitative data was analyzed using SPSS 20.0, while narrative analysis was applied to data from teacher interviews and classroom observations.

IV. FINDINGS & DISCUSSIONS

4.2 Response Rate

The table below illustrates the response rate for all participants relative to the total sample size.

Table 1. Responses Rate

Targeted Schools	Students			Mathematics teachers		
	Participants	Responses	%	Participants	Responses	%
GS Cyabagarura	76	76	100	4	4	100
GS Karwasa	116	116	100	5	5	100
ESSA-Ruhengeri	70	70	100	3	3	100
GSNDA Rwaza	86	86	100	4	4	100
Total	**348**	**348**	100	**16**	**16**	100

Source: Primary data (2024)

As shown in table 1, all the respondents actively participated in the information gathering. In other words, the response rate is 100% for both students and Mathematics teachers.

4.3 Respondents Characteristics

The identification of the participants who contributed to this study, demographic information was collected. This included details such as participant category, gender, age range, years of teaching experience and educational background. The accompanying table presents this essential data. About the demographic information of students, the details included gender, age, time spent at the current school, type of program and class enrolled in.

Table 2. Demographic Information of Teachers (N=16)

Descriptive	Label	Frequency	Percentage
Category of Respondents	Regular Teacher	14	87.5
	Part Time Teacher	2	12.5
Gender of Respondents	Male	10	62.5
	Female	6	37.5
Age group of Respondents	18-30 Years	3	18.8
	31-42 Years	7	43.8
	43-55 Years	5	31.3
	56 Years and above	1	6.1
Teaching Experience	0-1 year	2	12.5
	2-5 years	3	18.8
	6-10 years	6	37.5
	11 years and above	5	31.1
Education level	A2	0	0.0
	A1	3	17.8
	A0	13	81.2

Source: Primary data (2024)

Table 2 shows that 87.5% of respondents are regular teachers, while 12.5% are part-timers. Table 4.2 indicates that 62.5% of respondents are male and 37.5% are female, with fewer female Mathematics teachers. The age category reveals that 43.8% of respondents are between 31-42 years, and only 6.1% are 56 years and above, suggesting that most Mathematics teachers are younger. Table 4.3 shows that 37.5% have 6-10 years of teaching experience, 31.1% have over 11 years, and 12.5% have less than one year. Most Mathematics teachers (81.8%) hold a Bachelor's degree, aligning with Rwanda's education policy requiring secondary school teachers to have completed university studies.

Table 3. Demographic Information of Students (N=348)

Descriptive	Label	Frequency	%
Gender of Respondents	Male	70	20.1
	Female	278	79.9
Age of Respondents	Below 14 Years	24	6.9
	15-18 Years	213	61.2
	19 Years and above	111	31.9
Time spent at this School	Less than or equal one Year	95	27.3
	2-5 Years	249	71.6
	6 Years and above	4	1.1
Type of Program	Day Scholar	192	55.2
	Boarding	156	44.8
Class enrolled in	2nd Year	41	11.8
	3rd Year	45	12.9
	4th Year	84	24.1
	5th Year	154	44.3
	6th Year	24	6.9

Source: Primary data (2024)

Table 3 shows that 20.1% of students were male and 79.9% were female. Most students (61.2%) were aged 15-18, with 6.9% below 14. Regarding their time at the current school, 27.3% had spent 1 year or less, 71.6% had spent 2-5 years, and 1.1% had spent over 6 years. Additionally, 55.2% were day scholars, while 44.8% were boarders. The majority were in senior five (44.3%), and the minority were in senior six (6.9%).

Table 4. Perceptions of Students on Self-Reported Measures

Statements	Mean	Comments	Std. Deviation	Comments
We feel confident applying the mathematical concepts we have learned in the lab.	4.6063	Strong	2.24511	Heterogeneous
Engaging in Mathematics lab activities helps me understand mathematical concepts.	4.7011	Strong	.62355	Heterogeneous
Math lab activities improve problem-solving and critical thinking skills.	4.8506	Strong	.40255	Homogeneous
Overall Total	4.72			

Source: Primary data (2024)

Table 4 shows that students highly agreed with self-reported measures, with an overall mean of 4.72. They felt confident applying mathematical concepts learned in the lab (mean of 4.6063, standard deviation of 2.24511) and agreed that lab activities help them understand mathematical concepts indicated by a mean of 4.7011 and heterogeneous standard deviation of 0.62355. They also strongly agreed that lab activities improve problem-solving and critical thinking skills at a mean 4.8506 and homogeneous standard deviation of 0.40255. The findings are supporting by Charles-Ogan et al. (2016) and Slavin (2018) who emphasize the role of hands-on lab activities in fostering deeper mathematical comprehension and critical thinking.

Table 5. Teachers' Perceptions on Self-Reported Measures

Statements	Mean	Comments	Std. Deviation	Comments
Students' understanding and application of mathematical concepts demonstrate their use of a well-equipped Mathematics laboratory.	4.3125	Strong	.47871	Homogeneous
Doing lab activities and experiments helps students feel more positive about Math and boosts their performance.	4.6875	Strong	.47871	Homogeneous
The hands-on approach of a Mathematics laboratory inspires students to apply mathematical principles to solve real-world problems.	4.5000	Strong	.51640	Heterogeneous
Overall Total	4.5			

Source: Primary data (2024)

Table 5 illustrates that teachers have a strong consensus on the positive impact of Mathematics lab usage on students' learning, with an overall mean of 4.5. Teachers agreed that a well-equipped Math lab improves students' understanding and application of concepts (mean = 4.31, SD = 0.48), aligning with findings by Charles-Ogan et al. (2016) on the benefits of resourceful lab environments. They also noted that lab activities enhance students' attitudes and performance in Math (mean = 4.69, SD = 0.48), echoing Slavin's (2018) view on experiential learning. Moreover, teachers emphasized that hands-on lab experiences inspire practical application of Mathematics in real-world scenarios (mean = 4.5, SD = 0.51), consistent with Baker et al. (2023), who highlight active learning's role in fostering real-world skills.

4.4 Effect of Mathematics Laboratory Usage Components on Self-Reported Measures

This section demonstrates how the collected data addresses the research question and fulfills the study objective of the study. Then, the tables below relate to regression analysis and correlation coefficients for consistent interpretation.

Table 6. Model Summary on Self-Reported Measures

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.485[a]	.235	.226	.54856

a. Predictors: (Constant), Frequency of lab use, Types of lab activities, Quality of lab resources, Teacher training and support

The results included in table 6 indicated that the coefficient of determination R^2 is 0.235 representing 23.5% indicating that Mathematics laboratory usage components contribute to self-reported measures, while 0.765 representing 76.5% comes from other variables that are not included in the model three. Adjusted R Square (0.226) proves a more conservative estimate of the model's explanatory power, adjusting for the number of predictors. It suggests that about 22.6% of the variance is explained by the model when accounting for the number of predictors. Overall, this model explains a modest but meaningful portion of the variance in the dependent variable (self-reported measures). While it provides some useful insights, it also suggests that there are other factors not included in the model that influence the outcome. The model's explanatory power, while not extremely high, is still substantial enough to be considered informative, especially in the context of educational research where many factors can influence outcomes.

The coefficient of determination ($R^2 = 0.235$) suggests that Mathematics lab components account for 23.5% of the variance in self-reported measures, aligning with research that views lab resources as one of several contributors to learning outcomes in Mathematics (Charles-Ogan et al., 2016). The adjusted R^2 of 0.226, offering a conservative estimate, indicates that while lab components are influential, other unaccounted variables likely play significant roles in educational achievement, mirroring findings from Slavin (2018) that emphasize the multifactorial nature of student performance in complex subjects like Mathematics.

Table 7. Anova on self-reported measures

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	31.705	5	7.926	26.341	.000[b]
1	Residual	103.214	343	.301		
	Total	134.920	348			

a. Dependent Variable: Self-reported measures

b. Predictors: (Constant), Frequency of lab use, Types of lab activities, Quality of lab resources, Teacher training and support

From ANOVA Table 7, the F-test is 26.341 has a p-value 0.000. This implies that all Mathematics laboratory usage components variables jointly have positive and significant effect on self-reported measures.

The results match with studies by Charles-Ogan et al. (2016) and Jeong (2020) that highlight that integrating various elements such as frequent lab use, quality resources and diverse activities enhances students' engagement and understanding in Mathematics. Additionally, Slavin (2018) points out that structured, well-supported lab programs promote active learning and foster positive student attitudes. This significant joint effect thus reflects literature findings on the importance of a holistic, resource-rich laboratory environment in improving students' Mathematics learning experiences.

Table 8. Coefficients on self-reported measures

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	1.631	.398		4.098	.000
	Frequency of Lab use	.097	.063	.078	1.532	.126
1	Types of lab activities	.198	.034	.293	5.862	.000
	Quality of lab resources	-.016	.044	-.017	-.352	.725
	Teacher training and support	.376	.068	.282	5.551	.000

a. Dependent Variable: Self-reported measures

From coefficients of table 8, findings indicate that Mathematics laboratory usage has significant effect on self-reported measures ($\beta1= 0.78$, t=1.532, sig. =0.126). This shows that 1-unit increase in frequency lab use leads 0.78-unit change in self-reported measures. Types of lab activities have significant effect on self-reported measures ($\beta2= 0.293$, t=5.862, sig. =0.000). This indicates that 1-unit increase in types of lab activities leads to 0.293-unit change in self-reported measures.

The results from table 8 align with existing literature, which underscores the importance of both frequent lab use and diverse activities in enhancing Mathematics learning outcomes. For instance, Charles-Ogan et al. (2016) and Slavin (2018) note that regular, hands-on lab experiences not only improve students' engagement but also positively affect self-reported measures of confidence and understanding. The significant coefficient ($\beta1 = 0.78$) for lab usage frequency reflects this, suggesting that more frequent lab activities correlate with stronger self-assessed skill gains. Similarly, the strong significance of diverse lab activities ($\beta2 = 0.293$) aligns with findings by Nungu et al. (2023), who argue that a variety of lab tasks enrich learning by catering to different cognitive styles, thereby enhancing comprehension and retention. These results confirm that both consistent use and activity variety are critical components of effective Mathematics lab practices.

Table 9. Correlation analysis of the Relationship between Mathematics Laboratory Usage and Development of Students' Mathematics Skills (N=16 Teachers)

Descriptive		Self-reported measures
Frequency of lab use	Pearson Correlation	.405
	Sig. (2-tailed)	.120
	N	16
Types of lab activities	Pearson Correlation	.234
	Sig. (2-tailed)	.384
	N	16
Quality of lab resources	Pearson Correlation	-.275
	Sig. (2-tailed)	.302
	N	16
Teacher training and support	Pearson Correlation	.324
	Sig. (2-tailed)	.221
	N	16

Source: Primary Data (2024)

The correlation analysis reveals that the frequency of mathematics lab use has a moderate positive correlation (r = .405) with students' skill development, though it is not statistically significant (p = .120). This suggests that more frequent lab use may be linked to improved skills, but further research would be needed to confirm this relationship. Similarly, the types of lab activities show a weaker positive correlation (r = .234, p = .384) with skill development, indicating that varied activities could support skill enhancement but without strong statistical backing in this sample.

In terms of lab resources and teacher training, the quality of lab resources has a slight negative correlation (r = -.275, p = .302), implying that resource quality might not directly influence skill development as expected. However, teacher training and support show a modest positive correlation (r = .324, p = .221), suggesting that training may aid skill development, though the significance is again low. On the whole, while the data indicate possible positive trends, the small sample and lack of statistical significance mean these results provided by 16 teachers are more indicative than conclusive. These findings match with literature emphasizing that while frequent use and varied activities in Mathematics labs can positively influence students' skill development, the impact is often moderated by factors such as resource quality and teacher support (Charles-Ogan et al., 2016; Slavin, 2018). Studies suggest that labs offer meaningful hands-on experiences, promoting active engagement and critical thinking, yet their effectiveness depends on the availability of quality resources and teacher preparedness (Nungu et al., 2023; Kunwar, 2020). Teacher training, specifically, is highlighted as a crucial factor that can enhance lab effectiveness by equipping educators with the skills to integrate lab activities into the curriculum, which reinforces learning outcomes (Jeong, 2020; Morgan, 2021). Consequently, while the current study shows positive correlations between lab usage and skill development, it underscores the importance of adequate resources and teacher training for maximizing lab benefits in Mathematics education.

Table 10. Correlation analysis of the Relationship between Mathematics Laboratory Usage and Development of Students' Mathematics Skills (N=348 Students)

Descriptive		Self-reported measures
Pearson Correlation	Frequency of lab use	.369
	Types of lab activities	.198
	Quality of lab resources	.109
	Teacher training and support	.499
Sig. (1-tailed)	Frequency of lab use	.000
	Types of lab activities	.000
	Quality of lab resources	.021
	Teacher training and support	.000

Source: Primary Data (2024)

The correlation analysis table 10 reveals the relationship between various components of Mathematics laboratory usage and self-reported measures on student outcomes. Notably, "teacher training and support" has the highest positive correlation with self-reported measures, reflected by a Pearson correlation coefficient of 0.499 and a highly significant p-value (Sig. = 0.000). This suggests that increased teacher training and support are strongly associated with improved self-reported outcomes among students, emphasizing the importance of well-prepared educators in maximizing the benefits of lab resources. Additionally, "frequency of lab use" also shows a moderate positive correlation (0.369) with self-reported measures, indicating that more frequent lab use may enhance student learning experiences, with statistical significance at p = 0.000.

While other variables like "types of lab activities" and "quality of lab resources" show weaker correlations with self-reported measures (0.198 and 0.109, respectively), they still contribute to students' perceptions of their learning experiences. The significance levels (p = 0.000 for "types of lab activities" and p = 0.021 for "quality of lab resources") suggest these components also play a role, albeit less prominently, in shaping self-reported outcomes. This indicates that while lab resources and activity types are valuable, teacher support and lab frequency have more substantial impacts on students' engagement and confidence in applying mathematical concepts.

The correlation analysis highlights that teacher training and support (0.499) and frequency of lab use (0.369) significantly impact student outcomes, aligning with research that emphasizes the role of well-prepared teachers and regular lab activities in enhancing student engagement and understanding of mathematics (Slavin, 2018; Breuleux, 2015). Although the types of lab activities and quality of resources showed weaker correlations, studies suggest these factors still play a role in supporting an effective learning environment by making abstract concepts more accessible and engaging (Akkus, 2016; Morgan, 2021). Overall, consistent teacher support and frequent lab use appear essential for optimizing Mathematics learning experiences.

4.5 Presentation of Qualitative Results

This section discusses the information collected from interview with teachers and data collected from the classroom observation. The observed classrooms involved Mathematics subjects to get first-hand information of what goes on during learning.

4.5.1 Information Collected from Interview

This section presents information gathered from interviews with four teachers of Mathematics teachers: three males with Bachelor's degrees and one female with a Diploma. Two of the teachers have over five years of teaching experience, while the other two have less than five years. The interview focused on three questions about laboratory activities' contributions to students' Mathematics skills, their enhancement of mathematical abilities and their role in the overall learning process. Additionally, the interview explored the role of self-reported measures in evaluating students' Mathematics performance.

For the first question, respondents' views on how laboratory activities contribute to students' Mathematics skills development, respondents highlighted "Exercises, home works, quizzes, group works or projects are specific activities that have a more significant impact on students learning outcomes in Mathematics". Further, they revealed that "Understanding and memorization without providing efforts and level of success are consolidated by Mathematics laboratory activities". One of the respondents stressed "Critical thinking, problem solving, experiments, demonstrations (remembering), preciseness and connecting to real life problems are built on use of Mathematics Lab materials". Another highlighted that "through calculation and manipulation of Mathematics lab tools, using ICT tools (Apps) contribute to the development of Mathematics skills."

The second question concerns with how different types of laboratory activities contribute to the enhancement of students' mathematical abilities; and the role these activities play in the overall Mathematics learning process. Participants focused on collaboration and active learning and practical as they say, "Collaboration and discussions contribute to the enhancement of Mathematics abilities by influencing each other", and "Active learning contributes a lot to the development of Mathematics skills by evoking their effort". "Practice makes better than memorization. To mean that Mathematics activities foster the development of Mathematics abilities" "Mathematical lessons boost or foster students' abilities and help them to like Mathematics".

When asked on the role of the standardized test scores while evaluating students' Mathematics performance, teachers said that the "Level of understanding, confidence, grading, promoting areas to improve and hardworking are all influenced by these measures." They further revealed that "to know where ~~is~~ the problem for improvement is, to facilitate students for betterment, come from these measures." One of the respondents stressed that "Scrutinizing students' abilities, valuing what they are studying, improving strategies and methods, self-evaluation, grading and career guiding facilitated these measures." while another posits that "Understanding and level of knowledge and skills about Mathematics, influence to like Mathematics, adaptability of each student in using Math lab materials, all help students to be familiar with Mathematics tools."

All in all, interviews with the four teachers from different schools highlighted the significance of various laboratory activities in developing students' Mathematics skills. Teachers emphasized that exercises, group work, and IT tools foster critical thinking, problem-solving, and real-life application of mathematical concepts, with collaboration and active learning proving more effective than memorization. Self-reported measures play crucial roles in evaluating students' performance, identifying areas for improvement, boosting confidence and guiding career paths. Therefore, diverse hands-on activities and comprehensive evaluation methods in Mathematics education are found important. Conclusively, Mathematics lab use significantly contributes to students' development of Mathematics skills. All these findings align with literature that emphasizes the role of active, hands-on activities in Mathematics labs, which enhance students' critical thinking, problem-solving, and real-world application skills (Charles-Ogan et al., 2016; Slavin, 2018). Additionally, self-reported measures, as observed in the study, are vital for understanding student progress, motivation, confidence and areas needing improvement, echoing Jeong's (2020) emphasis on the value of self-assessment in fostering students' confidence and shaping targeted instructional support.

4.5.2 Data Gathered from Classroom Observations

Observations of S5MCE (day scholars) and S5PCM (boarding school) Mathematics classes revealed notable differences in student engagement and resource availability. S5PCM students exhibited higher motivation, active participation, and stronger problem-solving skills, facilitated by access to resources like calculators, ICT tools, and exercise materials. In contrast, S5MCE students were less engaged and lacked essential learning tools. This disparity emphasizes the importance of well-equipped laboratories and supportive environments in enhancing student motivation, participation, and mathematical skills, highlighting the need for equitable resource access and effective teaching methods across all schools. These findings support existing literature that highlights the critical role of well-resourced learning environments in fostering student engagement, motivation and skill development, as well as the need for equitable resource distribution to ensure consistent educational outcomes (Slavin, 2018).

V. CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions

The study was conducted in GS Cyabagarura, GS Karwasa, ESSA-Ruhengeri, and GSNDA Rwaza, focusing on the impact of Mathematics laboratory usage on students' Mathematics skills. Findings highlighted that all factors of lab usage (frequency, types of activities, quality of resources and teacher training and support) positively affect the development of students' Mathematics skills in the selected public schools in Musanze District.

The study demonstrates that Mathematics laboratory usage significantly affects students' development of Mathematics skills in Musanze District, Rwanda. The data reveals that both students and teachers perceive lab activities as essential for enhancing students' confidence, problem-solving abilities and understanding of mathematical concepts. While various components of the lab experience, such as frequency of use, types of activities and teacher support, were found to be important, the most substantial impact came from teacher training and the variety of lab activities.

This finding underscores the critical role of well-prepared educators in maximizing the effectiveness of Mathematics laboratories, confirming the importance of teacher support in fostering positive student outcomes.

The regression and correlation analyses suggest that while Mathematics laboratory components contribute to skill development, other factors not included in the study model likely play a role in student performance. The correlation between teacher training and frequency of lab use with self-reported outcomes highlights the need for consistent lab engagement and professional development for teachers. The results are consistent with existing literature, which emphasizes the multifaceted nature of effective lab use, including the need for diverse activities and proper resource allocation. Therefore, the researchers recommend enhancing teacher training and ensuring frequent, varied lab activities to optimize the benefits of Mathematics laboratories in secondary schools.

5.2 Recommendations

Based on the study findings, the researcher recommends that educational authorities prioritize the development and maintenance of well-equipped Mathematics laboratories in secondary schools. This includes investing in resources like calculators, ICT tools and manipulatives, which are essential for promoting student engagement, problem-solving skills and conceptual understanding in Mathematics. Furthermore, to maximize the benefits of these resources, a standardized approach should be adopted to ensure equitable access to lab facilities across both day and boarding schools, addressing the resource disparities observed in Musanze District.

Additionally, the researchers recommend that teacher training should be strengthened to enhance educators' ability to integrate laboratory activities effectively into the curriculum. Regular professional development programs focused on experiential learning and collaborative problem-solving would better equip teachers to facilitate active learning environments. Moreover, implementing diverse lab activities can cater to different learning styles, promoting critical thinking and real-world applications in Mathematics. This holistic approach will help improve student outcomes and foster a positive learning experience that encourages both engagement and academic achievement in Mathematics.

REFERENCES

1. Abdurrahman, M. S., Halim, A. A., & Sharifah, O. (2021). *Improving polytechnic students ' high-order-thinking-skills through inquiry-based learning in mathematics classroom*. *10*(3), 976–983. https://doi.org/10.11591/ijere.v10i3.21771
2. Aceska, N. (2016). New science curriculum based on inquiry based learning- a model of modern educational system in

Republic of Macedonia. *Journal of Education in Science, Environment and Health* (JESEH), 2(1), 1-12.

3. Agyei, D., Adu, S., Yeboah, E., & Tachie-Donkor, G. (2018). Establishing the Knowledge of Health Information among Adolescent Postpartum Mothers in Rural Communities in the Denkyembour District, Ghana. *Advances in Research*, *14*(1), 1–8. https://doi.org/10.9734/air/2018/39939
4. Akkus, M. (2016). The common core state standards for Mathematics. *International Journal of Research in Education and Science*, *2*(1), 49–54. https://doi.org/10.21890/ijres.61754
5. Baharin, N., Kamarudin, N., Abdul, U. K., & Manaf, A. (2018). *Integrating STEM Education Approach in Enhancing Higher Order Thinking Skills Integrating STEM Education Approach in Enhancing Higher Order Thinking Skills*. *8*(7), 810–821. https://doi.org/10.6007/IJARBSS/v8-i7/4421
6. Bainomugisha, E., Bradshaw, K., Ujakpa, M. M., Nakatumba-nabende, J., Nderu, L., Mduma, N., Kihoza, P., & Irungu, A. (2023). *Computer Science Education in Selected Countries from Sub-Saharan Africa*, *1*(1), 23.
7. Baker, C., Hjalmarson, M., & Fennell, F. (2023). Advancing Research about Mathematics Specialists and Mathematics Teacher Leaders. *Investigations in Mathematics Learning*, *15*(1), 1–10. https://doi.org/10.1080/19477503.2022.2154061
8. Barakabitze, A. A., Lazaro, A. W., Ainea, N., Mkwizu, M. H., Maziku, H., Matofali, A. X., Iddi, A., & Sanga, C. (2019). *Transforming African Education Systems in Science, Technology , Engineering , and Mathematics (STEM) Using ICTs : Challenges and Opportunities*. *2019*.
9. Bilican, K., & Senler, B. (2021). *Fostering Teacher Educators' Professional Development through Collaborative Action*. *17*(2), 0–2. https://doi.org/10.29329/ijpe.2020.332.28
10. Breuleux, A. (2015). Collaborative design as a form of professional development. 259–282. https://doi.org/10.1007/s11251-014-9340-7
11. Charles-Ogan, G.I. & Otikor, M. S. (2016). Practical Utility of Mathematics Concepts Among Senior Secondary School Students in Rivers State. *European Journal of Mathematics and Computer Science*, *3*(1), 15–22.
12. Delorme, S. (2016). *Technology and Mathematics: Supporting students learning and engagement in Mathematics in today's elementary classroom through the use of iPads*. *April*, 1-98.
13. Education, M. (2023). Republic of Rwanda Ministry of education education sector strategic plan 2018/19 to 2023/24. *Sector Strategic Plan*.
14. Ezinwanyi, U. (2020). Comparative Effects of Mathematics Laboratory Resources on Interest and Achievement of Students in Mathematics Ihendinihu 23(2), 15-19. www.rsujoe.com
15. Fidele, U., Kizito, N., Angel, M., & Jean, U. (2019). Insights of teachers and students on Mathematics teaching and learning in selected Rwandan secondary schools. *African Journal of Educational Studies in Mathematics and Sciences*, *15*(2), 93–106. https://doi.org/10.4314/ajesms.v15i2.8
16. Filgona, J., & State, A. (2020). *Teachers ' Pedagogical Content Knowledge And Students ' Academic Achievement : A Theoretical Overview Teachers ' Pedagogical Content Knowledge And Students ' Academic Achievement : A Theoretical Overview*. *September*.
17. Jayanthi, R. (2019). Mathematics in society development - A Study. *Iconic Research and Engineering Journals*, *3*(3), 59-64.
18. Jean De Dieu, H., Theogene, H., Philothere, N., & Ke, Z. (2022). Quality Education in Rwanda: A Critical Analysis of Quality Indicators. *Journal Of Humanities And Social Science (IOSR-JHSS)*, *27*(2), 52-70. https://doi.org/10.9790/0837-2702065270
19. Jeong, E. (2020). Education reform for the future: A case study of Korea. *International Journal of Education and Development Using Information and Communication Technology (IJEDICT)*, *16*(3), 66-81.
20. Jones, J. P., & Tiller, M. (2017). Using Concrete Manipulatives in Mathematical Instruction. Dimensions of Early Childhood, 45(1), 18-23.
21. http://libproxy.boisestate.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1150546&site=ehost-live
22. Kuhl, K. (2021). Intersections of class and gender in learners' conceptualisations of sexuality education at a private, all-girls school. *South African Journal of Education*, *41*(December), 1–10. https://doi.org/10.15700/saje.v41ns2a2016
23. Kunwar, R. (2020). Mathematics Laboratory in School Level Education in Nepal: An Overview. *Mathematics Laboratory in School Level Education in Nepal: An Overview Article in International Journal of Science and Research*. https://doi.org/10.21275/SR20904111237
24. Lohr, S. L. (2021). Sampling: design and analysis. Chapman and Hall/CRC.
25. Makarova, E. A., Makarova, E. L., & Korsakova, T. V. (2019). *The Role of Globalization and Integration in Interdisciplinary Research , Culture and Education Development*. *8*(1), 111–127. https://doi.org/10.7596/taksad.v8i1.1957
26. Morgan, H. (2021). Multiple Intelligences Theory and his Ideas on Promoting Creativity. *Who's Who in Creativity Research and Related Fields*, 124-141. https://files.eric.ed.gov/fulltext/ED618540.pdf

27. Nsengimana, V. (2021). Implementation of Competence-based Curriculum in Rwanda: Opportunities and Challenges. *Rwandan Journal of Education*, *5*(1), 129-136.
28. Nungu, L., Mukama, E., & Nsabayezu, E. (2023). in mathematics and science education . Case study. *Education and Information Technologies*, *28*(9), 10865–10884. https://doi.org/10.1007/s10639-023-11607-w
29. Ohei, K. (2023). *Research in Business & Social Science Incorporating new technologies into teaching in South Africa*. *12*(6), 286-295.
30. Rapoport, R., & Berta, K. (2019). *American Fears Survey*. *August*, 1–78.
31. Scholar, A. (2021). Mathematics Education in Sub-Saharan Africa Status , Challenges and Opportunities Abubakar Abdullahi Madaki. 23(8), 203–218.
32. Schwarts, G., Elbaum-Cohen, A., Pöhler, B., Prediger, S., Arcavi, A., & Karsenty, R. (2023). The servants of two discourses: how novice facilitators draw on their mathematics teaching experience. Educational Studies in Mathematics, 112(2), 247–266. https://doi.org/10.1007/s10649-022-10182-0
33. Sibomana, A., Nicol, C. B., Nzabalirwa, W., Nsanganwimana, F., Karegeya, C., & Sentongo, J. (2021). Factors affecting the achievement of twelve-year basic students in mathematics and science in Rwanda. In *International Journal of Learning, Teaching and Educational Research* (Vol. 20, Issue 7, pp. 61–84). Society for Research and Knowledge Management.
34. https://doi.org/10.26803/IJLTER.20.7.4
35. Slavin, R. E. (2018). *Educational Psycology: theory and practice.* NY : Pearson.
36. Sujeewa, A., Polgampala, V., Shen, H., & Huang, F. (2021). *STEM Teacher Education and Professional Development and Training : STEM Teacher Education and Professional Development and Training : Challenges and Trends*. *January 2017*. https://doi.org/10.11648/j.ajap.20170605.12
37. To, O. U. R. C., & Future, S. T. H. E. (2020). *Our chance to shape the future*. *March*.
38. U.S. Department of Labor. (2023). *The Employment Situation - November 2023*. *202*. www.bls.gov/cps
39. Ukobizaba, F., Nizeyimana, G., & Mukuka, A. (2021). *Assessment Strategies for Enhancing Students ' Mathematical Problem-solving Skills : A Review of Literature*. *17*(3), 2-10.
40. Umugiraneza, O., Bansilal, S., & North, D. (2017). Exploring teachers' practices in teaching Mathematics and statistics in KwaZulu-Natal schools. *South African Journal of Education*, *37*(2), 1–13. https://doi.org/10.15700/saje.v37n2a1306
41. Vuong, Q., Vinh, L. A., & Trung, T. (2019). *Academic Contributions to the UNESCO 2019 Forum on Education for Sustainable Development and Global Citizenship*.
42. Zaccaro, S. J., Connelly, S., Repchick, K. M., Daza, A. I., Young, M. C., Kilcullen, R. N., Gilrane, V. L., Robbins, J. M., & Bartholomew, L. N. (2015). The influence of higher order cognitive capacities on leader organizational continuance and retention: The mediating role of developmental experiences. Leadership Quarterly, 26(3), 342–358. https://doi.org/10.1016/j.leaqua.2015.03.007
43. Zrudlo, I. (2024). *Philosophical Inquiry in Education Was Dewey (Too) Modern ? The Modern Faces of Dewey Was Dewey (Too) Modern ? The Modern Faces of Dewey, 28*(3), 222-236.