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Impact of ICT Integration on Students' Performance in Mathematics in Public Upper Secondary Schools in Huye District, Rwanda

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Abstract: This study aimed to analyze ''Impact of ICT integration on students' performance in Mathematics in public upper secondary schools in Huye district, Rwanda. The study adopted a correlational research design. The target population size for this study was considered five schools consisting of 392 composed of 384 students and 8 mathematics teachers. A sample of 5 Mathematics teachers and 256 students from the five schools were selected for the study. The instrument used was a set of questionnaires; one for the Mathematics teacher and one for the students. By Statistical Package for Social Sciences (SPSS) version 25, descriptive and inferential statistics were used to answer the research questions and the Chi-Square analysis test was applied in testing the hypothesis formulated at a 0.05 level of significance. The outcome of the data collected revealed that the students taught with ICT tools performed better in Mathematics than their colleagues taught tools. The recommendations for higher performance of students in Mathematics were summarized in this study. These include: supporting all public upper secondary schools with sufficient ICT tools, to providing more training to Mathematics teachers on the use of ICT tools in teaching-learning Mathematics.

***Keywords**: Impact, ICT, Teaching, Mathematics, Students, Performance.*

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1. Introduction

Education is a vital input in the economic development of any country in the world (Breen, 2014). The educated population is an advantage to the development of a country and the root of an educated population starts with the performance at primary school (UNESCO, 2007).

Building an accurate inclusive society, where all people have access to education equally depends on providing a quality education for all. The Education for All (EFA) movement is a global commitment to providing quality basic education for all children, youth, and adults (UNESCO, 2007). The schools use Information and Communication Technologies (ICT) in different ways, such as using smartboards in classrooms and introducing smart classrooms while delivering lessons.

The methods and applications of the term ICT have been evolving rapidly, since 1980s when computers became relatively popular in education and progressively became available for the consumer. Towards the end of the 1980, the term ICT was replaced by Information Technology (IT), or a shift from computing technology to the capacity to store, analyze and retrieve information. The IT introduction was followed by the initiation of the Information and Communication Technologies in 1992, and the World Wide Web (Internet) became then public (Thangam, 2020).

Universal ICT policies have emerged in the last decade and underpinned an increase in productivity in many

public or private services such as healthcare, education, employment, and social development (United Nations, 2020). Since 1990, many administrations have adopted ICT in education, particularly to promote education as well as to recover the excellence of education. ICT has been identified as a means of attaining the globalization objectives as prescribed (School Net Africa, 2003).

The integration of ICT in teaching Mathematics is expected to promote understanding of abstract concepts like algebra, geometry, and trigonometry. The use of computer in Mathematics speeds up the graphing process but limits the sense of analyzing and reflecting on the relationships between data (Karadeniz & Thompson, 2017).

The general overview of students' performance in Mathematics in the HUYE district indicated that there was a relatively low performance over the past years (Uwineza et al, 2018). Thus, the problem of performance in Mathematics needs to be addressed. The main objective of this study is to analyze the impact of ICT integration in the teaching and learning process on students' performance in Mathematics.

The Rwandan government considers ICT as a main tool for changing the economy, by the education sector playing an important role in developing the essential human resources. Since 2000 computers were made available in schools for integrating ICT progressively into the education curriculum through a range of creativities (Rubagiza et al, 2011). The gap is still observed in the performance in Mathematics of students in upper secondary schools (Uwineza et al, 2018). The performance of students is still low in upper secondary schools while S6 students' grades are used as criteria of eligibility for higher education levels (University). Hence, the main purpose of this research is to analyze the impact of ICT integration in the teaching and learning process by stressing students' performance in Mathematics in public upper secondary schools in the Huye district.

2. Literature Review

The use of ICT enables opportunities for learning environments and practices that require interaction among individuals, cooperation with chances to experience and learn, and the principles which constructionism supports (Devajit et al, 2020). Many educational establishments, especially at the secondary school level, work on supporting integrating technology into teaching and learning.(Kristanto, 2021) provides an example of the integration of the internet for learning, as learners use the internet and explore it in different ways and different directions. In this research, small group discussion was used and their presentations after the research produced numerous interpretations of the subject matter.

ICT integration in education forms a critical entry point (Thangam, 2020). Furthermore, equipping institutions and keeping them active to time with ICT equipment is a very expensive operation not only due to the necessary hardware and software purchases but also because of the recurrent cost related to maintenance and sustenance.

2.1. Mathematics and ICT

Students use ICT in calculations, graphing, and solving problems. Besides that, spreadsheets, computer algebra systems, or graphical calculators can be used to solve problems through tests and improvement or retrieval methods. Creating an image in a dynamic geometry package can help the student to understand, then solve a problem. When students use ICT in their research or in solving problems, their skills in Mathematics are much more developed (Kaushik, 2019).

The integrating ICT in two dimensional and three-dimensional imagery was given a more realistic view to the learners. With the Internet, new information and data are always available to the learners (Kaushik, 2019). By different theories of trigonometry, it is possible to make ICT dependent on practical applications. Self-Regulated learners are aware of their abstract strengths and weaknesses and are well versed in the strategies they use to address the day-to-day tasks of abstract work (Treur, 2021).

2.2. ICT integration in teaching and learning Mathematics

ICT plays a meaningful role in changing and updating the educational system as well as the method of learning. By this perspective, teachers training in ICT tools should not just be about using new technologies but also about why and when to use them in transforming teaching and learning practices (Uworwabayeho, 2016). It is supposed that ICT can permit both Mathematics teachers and students and it may transform the teaching and learning process where ICT is integrated into Mathematics. With the integration of ICT, the students become more engaged in their effort and provide different occasions to make it more enjoyable in terms of teaching the same things in different ways and providing to students an opportunity to develop creativity and communication skills (Devajit et al, 2020).

2.3. Impact of ICT integration and students' performance in Mathematics

ICT is a potentially dominant tool for extending educational opportunities for secondary students in the Mathematics classroom. It is a new paradigm of the teaching-learning process. There are various ICT tools available that can be utilized for knowledge creation in the modern world. Tools include, Internet, computer, laptop, projector, and social media. Students of secondary level

use the Internet, computer, laptop, projector, and social media for learning during class time. Integration of ICT in these schools was done to attract students and improve their performance. ICT integration offers many benefits to enhance education. Most importantly, ICT integration has the potential to increase students' motivation and is a great way to reach diversity in learning styles.

It is supposed that ICT integration can empower both teachers and students. Integrating ICT in education transforms teaching and the learning process. ICT tools provide the students an opportunity to develop creativity or imagination, communication skills, and other thinking skills. Beyond the classroom wall, a full learning environment is wanted in which learners and teachers can easily communicate and collaborate to share secure information. By integrating ICT in teaching and learning in the classroom, students can learn more successfully, collaborate, and discover more concepts with others. By integrating ICT in teaching Mathematics difficult problems can be solved easily and very quickly. And also, integrating ICT in teaching Mathematics can help Mathematics teachers to express clearly what they want to express in the class and students to understand what the Mathematics teachers have expressed through demonstration, visualization, and experimentation (Aggarwal, 2020). Integrating ICT in Mathematics class makes students enjoy the audio and visual activities and the interaction among themselves and it also draws the student's attention toward learning.

3. Methodology

3.1. Research design

The study was conducted using the correlation research design. This was because its intention was to investigate the relationship between ICT integration in the teaching and learning process and students' performance in Mathematics. Data were collected using the questionnaire. The students enrolled in 5 public upper secondary schools in the Huye district (schools A and B taught with ICT tools and schools C, D and E taught without ICT tools) and their Mathematics teachers were given the questionnaires.

3.2. Population

The target population size for this study was considered five schools consisting of 392 composed of 384 students and 8 Mathematics teachers of public upper secondary schools of the science of Huye district.

3.3. Sample and Sampling Procedures

The study was conducted in the Huye district and was based on purposive sampling followed by stratified sampling and simple random sampling techniques. Purposive sampling was used to select five public upper secondary schools. The public upper secondary schools were divided into two strata namely the schools taught without ICT tools, in which Mathematics teachers used traditional teaching methods, and then schools taught ICT tools, where ICT tools were integrated into teaching and learning Mathematics. Purposive sampling was used to select Mathematics teachers and simple random sampling was used to select students from the five schools. A sample of 256 students and five Mathematics teachers was used in this study. To determine the sample size of the required representative sample, the following formula for the sample size calculation for a single proportion (Daniel, 2010) was used to calculate the minimum sample size as follows:

$$\mathbf{n} = \frac{Z^2 \mathbf{N} \mathbf{p}(\mathbf{1}-\mathbf{p})}{\mathbf{d}^2(\mathbf{N}-\mathbf{1})+\mathbf{z}^2\mathbf{p}(\mathbf{1}-\mathbf{p})},$$

$\boldsymbol{n} =$ is the minimum sample size to be determined, $\boldsymbol{N} =$ is the population size; $\boldsymbol{Z} =$ is the critical value of the Normal distribution at $\boldsymbol{\alpha}/\mathbf{2}$ (e.g. for a confidence level of $\mathbf{95}\%$, $\boldsymbol{\alpha}$ is $\mathbf{0.05}$ and the critical value is $\mathbf{1.96}$); $\boldsymbol{p}$ = is the sample proportion (when this is unknown, a standard choice is to take $\boldsymbol{p} = \mathbf{0.5}$), $\boldsymbol{d}$ = is the margin of error or relative desired precision ($\boldsymbol{d} = \mathbf{5}\%$ is a standard choice).

3.4. Validity and Reliability of research Instruments

This study used questionnaires to correct the data. Before the instruments were used for collecting data, a pilot study was conducted in two public upper secondary schools in the Huye district which had the same characteristics as the sampled schools. The instrument was validated and the reliability index of 0.852 was obtained. Cronbach's alpha coefficient was used to measure the interval consistency of the impact of ICT integration in the teaching and learning process on students' performance in Mathematics.

3.5. Data Analysis

Quantitative data were analyzed using descriptive statistics in IBM Statistical Package for the Social Sciences (SPSS), version 25. A Spearman Correlation Test was employed to illustrate the correlation between students' performance and ICT integration in the teaching and learning process in Mathematics. A Chi-square test was used to determine whether there is a significant relationship between the ICT integration in the teaching and learning process and students' performance in Mathematics.

4. Results and Discussions

4.1. Findings of results

The findings were discussed with regard to research objectives;

4.1.1. The level of performance of students in Mathematics in public upper secondary schools in the Huye district taught without ICT tools

The first objective in this study was to examine the level of Performance of Students taught tools in Mathematics. The results presented below are a result of data analysis about the Students' performance in public upper secondary schools taught tools, especially in combinations of Mathematics. We have analyzed the students' views about their performance at the end of the second term district assessment 2022 in Mathematics. In this study, students' performance was conceptualized in terms of five grades prompting each respondent to do self-rating in the second term of performance in second term examinations. Table 1 below illustrates the performance of the students and the number of student respondents for each interval of marks. Table 1 shows the distribution of the student's responses.

Table 1: Distribution of the students' responses to Students' Performance in schools taught without ICT tools (N=123)

Grade	Frequency	Percentages
Fail (0% - 49%)	75	61.0
Satisfactory (50% - 59%)	34	27.6
Good (60% - 69%)	8	6.5
Very good (70% - 79%)	5	4.1
Excellent (80% -100%)	1	0.8

Source: Field data (2022)

It has been established that 61% (75) of the students scored marks between (0%-49%) in the second term exam, 27.6% (34) of the students scored marks between (50%-59%), 6.5% (8) of the students scored marks between (60%-69%), 4.1% (5) of the students scored marks between (70%-79%) and 0.8% (1) of the students scored marks between (80%-100%). This shows that the students did not perform well as they learned Mathematics tools in their studies.

4.1.2. The level of performance of students in Mathematics in public upper secondary schools in the Huye district taught using the ICT tools

In this section, we present the results of data analysis with regard to the Students' performance in public upper secondary schools taught using ICT tools, especially in combinations of Mathematics. The students' views about their performance at the end of second term examinations in Mathematics. In this study, students' performance was conceptualized in terms of five grades prompting each respondent to do self-rating in the second term of performance in the second term district examinations 2022. Table 2 below presents percentages and headcount the number of students for each interval of marks.

Table 2: Distribution of the students' responses to Students' Performance in schools taught with ICT tools (N= 133)

Grade	Frequency	Percent	Cumulative percent
Fail (0% - 49%)	17	12.8	12.8
Satisfactory (50% - 59%)	28	21.0	33.8
Good (60% - 69%)	54	40.6	74.4
Very good (70% - 79%)	29	21.8	96.2
Excellent (80% -100%)	5	3.8	100.0

The result indicates that 12.8% (17) of the students scored marks between 0-49% in assignments, 21.0% of students scored marks between 50-59%, 40.6% (54) of the students scored marks between 60-69%, 21.8% (28) of the students scored marks between 70-79% and 3.8% (5) of the students scored marks between 80-100%. This shows that the students who learned Mathematics with ICT tools performed better.

4.1.3. The effect of ICT integration in teaching and learning Mathematics in public upper secondary schools of Huye District by comparing without and with ICT tools groups

Based on the assessment result of students' performance, the performance of students taught without ICT tools is low. In general, the majority of students had marks below 50% in Mathematics while the performance of students who learned Mathematics with ICT tools only 12.8% scored marks between 0% to 49%.

Table 3: Comparison of performance between students taught with ICT and without it

	Grade	School category	
		Teaching without ICT tools	Teaching with ICT tools
Students' performance	Fail (Below 50%)	75 (61)	17 (12.8)
	Satisfactory (50%-59%)	34 (27.6)	28 (21)
	Good (60%-69%)	8 (6.5)	54 (40.6)
	Very good (70%-79%)	5 (4.1)	29 (21.8)
	Excellent (Above 80%)	1(0.8)	5 (3.8)

f = Frequency, % = Percentage, Values in brackets are percentage of students with the school category. **Source: Field data (2022)**

As stated, students at public upper secondary schools were surveyed to capture an impression of their perceptions of the ICT integration in teaching and learning Mathematics on their performance.

T**able 4: Distribution of the student's responses on the impact of ICT integration in teaching and learning process on students' performance in Mathematics**

Statements	Strongly agree f (%)	Agree f (%)	Disagree f (%)	Strongly disagree f (%)
The use of projectors in teaching Mathematics affects how students understand Mathematics in class.	86 (33.6)	109 (42.6)	44 (17.2)	17 (6.6)
The use of a smart classroom in teaching and learning Mathematics affects how students understand Mathematics in class.	93 (36.3)	109 (42.6)	36 (14.1)	18 (7)
The use of the internet in teaching and learning Mathematics helps students to understand how Mathematics questions are set and handled.	85 (33.2)	109 (42.6)	47 (18.4)	15 (5.9)
Use of computers when teaching Mathematics affects the students' performance in Mathematics.	63 (24.6)	129 (50.4)	53 (20.7)	11(4.3)
The students' use the computers during Mathematics affects the students' performance in Mathematics.	76 (29.7)	114 (44.5)	45 (17.6)	21(8.2)
The teacher uses social media like YouTube that help the students to perform Mathematics lessons.	93 (36.3)	110 (43.0)	36 (14.1)	17 (6.6)
The ICT tools are very helpful in learning Mathematics for students.	66 (25.8)	127(49.6)	53 (20.7)	10 (3.9)
The ICT tools make learning Mathematics more interesting for students.	99 (38.7)	95(37.1)	41(16.0)	21(8.2)

f = Frequency, % = Percentage, Values in brackets are percentage of students who strongly agreed, or agreed, or disagreed, or strongly disagreed with the statements. **Source: Field data (2022)**

Table 4 above represented the summary results on the effect of ICT integration in teaching and learning Mathematics, the results obtained are as follows: the majority of the respondents, 42.6% agreed that the use of projectors in teaching Mathematics affects how students understand Mathematics in class, 33.6% strongly agreed, 17.2% disagreed, while 6.6% strongly disagreed with the statement.

Regarding the use of a smart classroom in the school, 36.3% of the respondents strongly agreed that the use of a smart classroom in teaching and learning Mathematics affects how students understand Mathematics in class, 42.6% just agreed, 14.1% of the respondents disagreed while 7% of the respondents strongly disagreed with the statement. A proportion of 42.6 % accepted that the use of the internet in teaching and learning Mathematics helps students to understand how Mathematics questions are set 33.2% strongly agreed, 18.4% disagreed, and 5.9% the respondents strongly disagreed with the statement. Among the respondents, 24.6% strongly agreed with the statement that the teacher uses social media like YouTube that helps the students to perform Mathematics lessons, 50.4% just agreed, 20.7% disagreed and 4.3% strongly disagreed with the statement. About 24.6% strongly agreed with the statement that the teacher uses computers when he teaches Mathematics affects the students' performance in Mathematics, 50.4% just agreed, 20.7% disagree and 4.3% strongly disagreed.

The results also indicate that 44.5% agreed that the students' use of computers during Mathematics affects the students' performance in Mathematics, 29.7% strongly agreed, 17.6% disagreed, and 8.2% strongly disagreed with the statement.

4.1.4. The relationship between ICT integration in the teaching and learning process and students' Performance in Mathematics in public upper secondary schools of the Huye district

The relationship is analyzed using cross-tabulation between the use of ICT and students' performance in the second term, 2022 academic year in the Huye district. The correlation between the ICT integration in teaching and learning and students' performance in Mathematics was determined using SPSS.

To determine if there is a significant relationship between the ICT integration in teaching and learning Mathematics on students' performance, the independent variable ICT integration in teaching and learning process was correlated with the dependent variable students' performance using the Spearman Correlation Test in the sampled schools. The result of the test is presented in table 5 below:

Table 5: Relationship between the ICT integration on Students' Performance

Correlation			ICT integration in teaching and learning	Students' performance
Spearman's rho	ICT integration in teaching and learning	Correlation Coefficient	1.000	.581**
		Sig. (2-tailed)	.	.000
		N	256	256
	Students' performance	Correlation Coefficient	.581**	1.000
		Sig. (2-tailed)	.000	.
		N	256	256

. Correlation is significant at the 0.01 level (2-tailed), sig. = significant, N = Number of students. **Source: Field data (2022)

As shown in table 4, findings showed that the relationship between the ICT integration in teaching and learning and students' performance was moderate as the Spearman's rho correlation coefficient equals to 0.581. The correlation between these two main variables was significant because the P-value was 0.000 which is less than 0.05. This implies that the independent variable ICT integration in the teaching and learning process has the potential to influence the performance of students in Mathematics. After getting the information from correlation analysis, we have tried to make a model which can predict the ICT integration in the teaching and learning process on the students' performance in Mathematics. The coefficient of the regression equation was obtained from SPSS and summarized in the table 6.

Table 6. Regression analysis of the ICT integration in teaching and learning on students' performance in Mathematics

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.357	.172		13.675	.000
	ICT integration	.702	.079	.486	8.860	.000

Findings from regression analysis showed that we can construct a linear equation showing the ICT integration in the teaching and learning process on students' performance in Mathematics. These results show that the slope of the equation is 0.652 and the constant is 2.517. These coefficients are significant as the significance values observed in the last column are less than 0.05. This means that when we know the mean x of frequency for the ICT integration in the teaching and learning process in Mathematics that we call a predictor, the level of performance for students can be predicted using the formulae: $y = 0.652x + 2.517$, where: y is the students' performance, x is the ICT integration in teaching and learning process.

4.2.Testing of hypothesis

To verify the hypothesis, a Chi-square test was carried out to test the null hypothesis that "there is no significant relationship between the ICT integration in teaching and learning on students' performance in Mathematics in public upper secondary schools in the Huye district. The chi-square test is used to test whether two variables under the study are independent or not. The results of the test are presented in table 7 below.

Table 7: Correlation analysis between ICT integration in teaching and learning process and Students' performance in Mathematics

Variables	Degree of freedom	p-value	calculated χ^2	Table χ^2	Decision
C1	12	0.05	166.360	21.026	Rejected
C2	12	0.05	96.526	21.026	Rejected
C3	12	0.05	86.891	21.026	Rejected
C4	12	0.05	71.923	21.026	Rejected
C5	12	0.05	69.734	21.026	Rejected

C1 = Use of projectors and Students' performance, C2 = Use of Smart Classroom and Students' performance, C3 = Use of Internet and Students' performance, C4 = Use of Social Media and Students' performance, C5 = Use of computers and Students' performance, χ^2 = Chi-square. **Source: Field data (2022)**

As shown in Table 5, the test on the relationship between ICT integration and performance of students in Mathematics using Chi-square test shows that use of projectors (χ^2 = 166.360**,** ρ = 0.000), use of Smart Classroom (χ^2 = 96.526, ρ = 0.000), use of Internet (χ^2 = 86.891, ρ = 0.000), use of Social Media like Youtube (χ^2 = 71.923, ρ = 0.000), use of computers (χ^2 = 69.734, ρ = 0.000) at 0.05 significance level. All the calculated χ^2 value is greater than the table χ^2 value of 21.026 as a result, the null hypothesis was rejected. This implies that the alternative hypothesis which says there is a significant relationship between the ICT integration in teaching and learning process on students' performance in Mathematics in public upper secondary schools in the Huye district is accepted.

4.3 Discussion

The findings of the study show that there is a significant relationship between the ICT integration in teaching and learning process on students' performance in Mathematics. The outcomes of the study showed that students who were taught with ICT tools performed better than those taught without it. These outcomes were supported by the findings of (Suparjan, 2021) who argued that students' performance increased when ICT tools are used in a lesson. It was further noted that Students' performance was found to decrease in a non-ICT tools-based lesson. Using ICT tools in lessons can enhance self-confidence leading to expectations of achieving goals. It is also supported by the outcomes of the studies of (Mittut, 2020) suggested that using ICT tools in lessons may help students in mastering subject skills. ICT tools used in lessons, especially in Mathematics produced higher quality output for students. From the above assertion, it can be concluded that ICT tools play a great role in improving the learning and performance of the students. The results are consistent with those (Okoro & Ekpo, 2016) who concluded that students taught through ICT performed better compared to those who were taught via the traditional method. Similarly, (Adhikari, 2021) concluded that ICT integration in the teaching and learning Mathematics has a positive impact on students' performance scores.

5. Conclusion and Recommendations

5.1Conclusion

Based on the findings of this study, it was concluded that there is a significant relationship between the ICT integration in the teaching and learning process on students' performance in Mathematics in public upper secondary schools in the Huye district. The students taught with ICT tools performed better than students taught without it.

5.2 Recommendations

Based on the findings of this study, the following recommendations are presented to improve or promote students' performance in Mathematics:

(i) The Ministry of Education in Rwanda (MINEDUC), may distribute the computers to the schools and to the teachers who are not yet used, ICT tools should be provided for all schools to make teaching real to students.

(ii) The Ministry of Education in Rwanda (MINEDUC), REB, and NESA should continue training the teachers on ICT knowledge and skills that are very critical to the teaching and learning process, and the old Mathematics teachers who are recruited should be encouraged to teach and train them and give them the skills and knowledge on how they use the ICT tools.

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