

## ICT Integration in Teaching and Learning Mathematics for Secondary Schools: Case of TTC Gacuba II, Rwanda

Viateur Irakarama<sup>1</sup>  
Alphonse Nteziyaremye<sup>2</sup>  
Jean Pierre Rukeribuga Kuradusenge<sup>3</sup>  
Vincent Bucyedusenge<sup>4</sup>  
Jean Claude Uwimana<sup>5</sup>  
Daniel Ndacyayisaba<sup>6</sup>

<sup>1</sup>iravia20@gmail.com  
<sup>2</sup>nitezalphonse1981@gmail.com  
<sup>3</sup>jpkuradusenge@gmail.com  
<sup>4</sup>vbucyedusenge@gmail.com  
<sup>5</sup>uwimanajc87@gmail.com  
<sup>6</sup>nddanielo30@gmail.com

<sup>1</sup><https://orcid.org/0009-0008-9444-9154>

<sup>2</sup><https://orcid.org/0009-0008-3081-7982>

<sup>1,2,4,5,6</sup>Rwanda Polytechnic, Karongi College, General Courses Department, <sup>3</sup>Teacher Training College Gacuba II, <sup>1,2,3,4,5,6</sup>Rwanda

### ABSTRACT

*ICT tools enhance the motivation and engagement of learners, and they can promote the shift to a learner-centered environment. As Mathematics is a key school subject, it is crucial to understand how ICT can be leveraged to enhance students' learning outcomes. This research aimed to identify the ICT tools and tools that math teachers utilize frequently, to find out the attitude of Mathematics tutors towards the use of ICT, and propose ICT tools to be used for improving Mathematics teaching and learning. The study was guided by both constructivism and Diffusion of Innovations (DOI) theories. The research is descriptive by nature as both qualitative and quantitative research methods were used in data collection and analysis. The target population of the study was 462 individuals of which 86 participants including 82 students, 3 tutors, and 1 IT manager were selected by both random and purposive sampling techniques. Questionnaires, interview guides, and observation checklists were used as tools to collect the needed data. Major findings are that ICT tools highly engage teachers and learners in different learning activities; ICT provides opportunities for students to interact with mathematical concepts and search for new things. Some new ICT tools, software and applications, were suggested to be used by students, teachers, and secondary schools. Lastly, this study recommends Mathematics teachers to integrate ICT into education to influence Mathematics performance as another alternative that would be used to resort to the traditional method of teaching and learning process while the school must organize continuous professional development activities related to the use of ICT tools for improving the teaching and learning process, as well as promoting the culture of using online classes like Google Classrooms to strengthen the applications that have been acknowledged and to update the acquired skills.*

**Keywords:** ICT, ICT Integration in Education, Secondary Schools, Teaching and Learning Mathematics

### 1. INTRODUCTION

Globally, mathematics is a crucial subject in school, yet it can be challenging for many students. For this reason, it is crucial to examine how digital tools can improve students' outcomes and other learner support (Viberg, Grönlund & Andersson, 2020). It has mostly focused on comprehending how educational institutions handle the process of digitizing ICT integration to enhance secondary school mathematics instruction and learning.

In a study conducted in Sweden, it was found that students struggle to effectively use technology when teachers do not establish shared practices for its use. When teachers do not actively utilize technology, they may not fully understand how students learn from it or be able to help them follow instructions. This results in conflicting teacher instruction and technology assistance. The study highlights the importance of integrating technology into the curriculum and promoting shared practices (Viberg, Grönlund, & Andersson, 2020).

A study conducted in South Africa found that the successful integration of ICT in mathematics teaching faced obstacles such as limited access to sufficient bandwidth, inadequate professional training in digital technologies, and

insufficient support from school management. Although digital technologies facilitated an interactive learning environment, the creation of high-level learning materials remained a significant challenge due to the lack of training and support for teachers (Netsianda & Ramaila, 2021). In Kenya, a study found that teachers encounter difficulties in incorporating ICT into math teaching due to a lack of technological skills and knowledge, as well as inadequate training and support. This results in a lack of enthusiasm for using technology in teaching (Amuko, Miheso & Ndeuthi, 2015).

Even though a number of digitization initiatives have been studied in several nations, little is known about how to effectively use Information and Communication Technology (ICT) in classroom to enhance learning and improve the conditions under which students can acquire mathematics, particularly, in the Rwandan context. More data have always been requested by academics in order to fully comprehend the complexity of technological innovation and change, and to enhance the mathematics teaching and learning process in secondary schools (Tondeur, 2012).

### 1.1 Problem Statement

Researchers have been highlighting the potential of ICTs to support mathematics learning when used in conjunction with good pedagogy for a few decades now. However, the use of digital technology in mathematics instruction does not, in the main, live up to their perceived potential to transform the learning experience, according to the findings of a recent assessment of empirical studies on the subject. Research has shown that students utilize ICT tools less frequently in classroom settings than in non-academic ones (Tangney, 2017). In order to improve student performance, more researches must be conducted on how ICT may be more effectively incorporated into mathematics instruction.

Moreover, according to UNESCO's ICT Competency Framework for Teachers, it is not enough for a teacher to have ICT competency; they must also be able to effectively teach students using ICT. Instead, it emphasizes the need for teachers to use ICT to help students become collaborative problem-solvers and creative learners and to develop into productive workers and citizens (UNESCO, 2011). The integration of ICT in Mathematics classrooms has shown promise, but its success depends on various factors such as the teachers' attitudes towards ICT's role in students' Mathematics learning and their perception of their ICT skills. However, there is a positive correlation between the use of ICT and students' learning (Comber, Fisher, & Lewin, 2022).

From the researchers' point of view, this research will play an essential significance in the improvement of the quality of modern technology, materials, and techniques that make the process of teaching and learning Mathematics in secondary schools smoother and more effective. Thus, this project is especially crucial in secondary because it considers ICT integration as a tool that supports the learning process and promises new solutions to some challenges that teaching and learning Mathematics is facing.

This study was conducted to investigate the extent to which ICT tools, provided to secondary schools in Rwanda, can enhance the teaching and learning of Mathematics. In this regard, studying the role of the ICT tools use in teaching and learning Mathematics is crucial because this research could guide ways to encourage greater technology use in Mathematics lessons. Additionally, it seeks to improve knowledge of how technology can be integrated into mathematics education to improve the functioning of complex information systems both inside and outside of the classroom.

### 1.2 Research Objectives

The specific objectives of this study are as follows:

- (i) To identify ICT tools utilized by Mathematics tutors in TTC Gacuba II classrooms;
- (ii) To investigate the perception of Mathematics tutors about the use of ICT in TTC Gacuba II;
- (iii) To propose the ICT tools that might be used for improving teaching and learning Mathematics in secondary schools.

## II. LITERATURE REVIEW

### 2.1 Theoretical Review

This study has been conducted around two major theories namely: Constructivism theory and Diffusion of Innovations (DOI) theory.

### 2.1.1 Constructivism Theory

The study was firstly done referring to Jean Piaget's constructivism theory (Brau, 2020). This theory highlights that a human being creates knowledge throughout interaction between his or her own experiences and ideas. As the constructivism theory is a learner-centered thinking, it stresses hands on learning and the learners being active in their learning (Nteziyaremye, Ndizeye & Murenzi, 2024). According to the constructivists paradigm, students actively create knowledge rather than merely absorbing it. This view is in line with the CBC, which was introduced in Rwandan school since 2015 (REB, 2015) whose purpose was to enable school graduates to persist to the challenges that they could meet and be able to deal with the labor market requirements (Rwanda Education Board [REB], 2015; Nsengimana, 2021).

Understanding how the teacher of mathematics might apply constructivism theory in the classroom is essential to provide the students with an excellent learning environment. For the students to take an active role in their learning, the teacher must establish a collaborative environment. Teachers ought to facilitate learning rather than simply educate. Therefore, teachers need to adjust their lessons based on the students' comprehension level and needs (WGU, 2020). Thus, it is the notion that the learning environment must be extremely adaptable to the student. Constructivism also views knowledge as fallible (nothing is certain; everything changes with time and space) and relativistic (nothing is absolute).

### 2.1.2 Diffusion of Innovations (DOI) Theory

Rogers Everett's (2003) Diffusion of Innovations Theory (DOI) applies to various domains including education. This theory postulates that teachers discover innovative teaching strategies and the finest ways to gain the academically required learners' performance level for promotion. When applied well, this theory allows the teachers to understand the most effective ways to reach learners' educational weaknesses that lead to their poor academic performance. Referring to DOI theory, the teachers can both improvise and innovate during their teaching activities (Mpumuje, 2024).

Relatively, to the topic at hand, it the teachers of Mathematics in secondary schools apply DOI theory, the teaching and learning process will always yield into improved students' performance in Mathematics subject as ICT tools in class attracts students. In this regard, the DOI theory is thought to be relevant to probe into ICT integration and use in teaching and learning to improve the learners' knowledge, skills, retention and attitude towards modern learning strategies to enhance academic performance (Mpumuje, 2024).

## 2.2 Empirical Review

The manner of education that leverages information and communication technology to optimize, improve and assist information delivery is known as "ICT integration in education", which refers to the use of technology in the field of education. International studies have demonstrated that ICT can result in enhanced student learning and more effective teaching strategies (Team, 2017). When teachers are digitally literate and trained to use ICT, this can lead to higher order thinking skills, provide creative and individualized options for students to express their understandings and leave students better prepared to deal with ongoing technological change in society and the workplace (Goodwin, 2012). Teachers' integration of ICT in teaching is also affected by organizational factors, attitudes towards technology and other factors (Chen, 2008; Tondeur, Braak & Valcke, 2008; Lim & Chai, 2008; Clausen, 2007). Additionally, Stockdill and Moreshouse (1992), Sherry and Gibson (2002) and Neyland (2011), in their studies, identified factors such as the user characteristics, content characteristics, technological considerations and organizational capacity to influence the adoption and integration of ICT in teaching process.

### 2.2.1 ICT Tools and Programs Utilized by Mathematics Teachers

Information and communication technologies (ICTs) can greatly enhance the quality of education. They can improve learner's motivation and engagement in the classroom, facilitate the acquisition of basic skills and enhance the teacher's ability to teach effectively. Moreover, when used appropriately, ICTs can help to transform the learning environment into a more learner-centered one. Instructors face challenges in adopting ICT tools, such as limited accessibility and network connection, inadequate technical support, insufficient training, time constraints and teacher competency (Ghavifekr, 2016).

To successfully initiate and implement educational technology in school's program depends strongly on the teachers' support and attitudes. It is, then, believed that if teachers perceive technology programs as neither fulfilling their needs nor their students' needs, it is likely that they will not integrate the technology into their teaching activities (Buabeng-Andoh, 2012). Among the factors that influence successful integration of ICTs in teaching are the teachers' attitudes and beliefs towards technology (Hew & Brush, 2007; Keengwe & Onchwari, 2008). If teachers' attitudes are

positive toward the use of educational technology, then they can easily provide useful insight about the adoption and integration of ICT in teaching (Buabeng-Andoh, 2012). Demici (2009) conducted a study on teachers' attitudes towards the use of Geographic Information systems (GIS) in Turkey. That study discovered that though barriers such as lack of hardware and software existed in their schools, the teachers' positive attitudes towards GIS played a major role to the success of integration of GIS in Geography classes.

Michael (2015) conducted a study on Plato and Socrates, in which he found that knowledge of geometry, existed even before a child was born. According to Plato, this knowledge is gained through the senses, by asking questions that awaken understanding of general concepts behind concrete phenomena. This suggests that students can excel in Mathematics if teachers help them to develop their knowledge, understanding, attitudes and skills related to mathematical concepts (Michael, 2015). Thus, the raised question is how teachers integrate ICT tools for improving the teaching and learning of Mathematics in secondary schools.

In this study, the teachers of Mathematics played a big role in preparing ICT tools and preparing a comfortable environment that helps the students to be attentive and productive in the improvement of teaching and learning Mathematics subject. In this research, ICT integration is related to several dynamic elements, such as efficient methods, the technological features of new tools, and the capacity to both enable and change teaching and learning processes. Perienen (2019) proposes using the Structural Practice Lens and the Information Systems Artifact (ISA) to handle the complexity of educational technology. The ultimate objective is for an individual to grasp a concept so well that they can apply it to novel situations or combine it with other concepts they have learned. Experiential education is likely the best approach to achieving this level of mastery, as it is closely linked to both the study and theory of the subject.

ICTs have a great potential to enhance educational opportunities for secondary students in Mathematics classrooms. There are numerous ICT tools available that can be utilized to create knowledge in the modern world. These tools include radio, TV, internet, mobile phones, calculators, computers, laptops, tablets, data projectors, printers, scanners, email, and other hardware and software applications. These tools can be used to benefit education and training for teachers and students of Mathematics in secondary schools (Devajit, 2020).

### **2.2.2 Attitude towards Integration of ICT Tools in Teaching Mathematics**

According to (Kamau, 2016), there is a connection between math teachers' perceived goals for integrating ICT into their lessons and laptop computer ownership. Compared to teachers who did not own a laptop, a greater percentage of math teachers who reported that these ICTs enhance students' learning. Results from other researches also highlighted a connection between the teachers' perceptions of ICT integration in the classroom and their methods of instruction which improve the students' performance (Mpumuje, 2021; Buabeng-Andoh, 2012). Teachers in national and county schools are probably going to think that ICT may help them become better facilitators of lessons and help pupils develop their communication skills. When opposed to district or community schools, national and county schools have better facilities for instruction. How instructors felt about ICT integration in the classroom was also influenced by the number of students enrolled in the classes under investigation. According to the findings, a higher percentage of math teachers who instructed classes with more than 40 students agreed that ICT improves students' academic progress than those who instructed classes with fewer than 40 students. According to this research, educators who work with classrooms larger than forty pupils can see ICT integration as a solution to the issues associated with these kinds of settings (Kamau, 2016).

In a study conducted by Fouzieh (2019) on mathematics teachers who were either in-service or pre-service, it was found that low levels of ICT integration were due to inadequate ICT competencies and limited access. The study evaluated the effect of computer attitudes, competencies and access on the teachers' levels of ICT integration, using the concepts of will, skill, and tool. Along with highlighting high levels of computer positivity, it also suggested that the preparation of teachers for new, flexible teaching approaches that make appropriate use of ICT is essential.

Theories of trigonometry can be practically applied using ICT, making it an important tool in education (Chong, 2005). Hence, the trained teachers in the use of integrating ICT in teaching and learning will apply it in Mathematics courses without failure. Various mathematical images of geometry can be presented to students using ICT tools such as a projector. The use of ICT in two-dimensional and three-dimensional imagery can provide a clear understanding to students. By utilizing the internet, new information and data are easily accessible to students.

### **2.2.3 ICT Tools that are Useful for Improving Teaching and Learning Mathematics**

The integration of Information and Communication Technology (ICT) in Mathematics classrooms has been a topic of discussion among Mathematics educators for a long time. Some examples of ICTs used in Mathematics teaching and learning include portable devices, graphic calculators, specialized software, programmable toys or floor

robots, spreadsheets, and databases. As demonstrated by various studies, there is a range of portable devices that allow students to collect data and manipulate it using spreadsheets and databases. Portable equipment allows for fieldwork investigations in Mathematics (Das, 2019; Ngamo, 2017). The use of graphic calculators and computerized graphing in Mathematics speeds up the graphing process, which allows individuals to analyze and reflect on the relationships between data more efficiently. Special software such as Computer Algebra Systems, Dynamic Geometry Systems, and Mathematics curriculum software improve pupils' skills and understanding of algebra, and allow learners to operate and measure shapes, leading to a higher level of learning (Henessy et al., 2001).

Many studies showed that teachers face obstacles when integrating ICT in classrooms. According to Agyei and Voogt (2010) and Snoeyink & Ertmer (2002), the lack of confidence among teachers when integrating ICT into lessons, their age, their inability to access resources, their lack of time for the integration, their lack of effective training, their inability to handle technical issues while using the software, and one of the obstacles that teachers face during lesson preparation is their lack of personal access.

### III. METHODOLOGY

#### 3.1 Study Area and Research Design

##### 3.1.1 Study Area

This study was conducted in a Teacher Training College (TTC) namely TTC Gacuba II, located in the Rubavu District, Western Province of Rwanda. It is a secondary school in nature that has an advanced level only, with four options: Science and Mathematics Education, Language Education, Social Studies Education, and Early Childhood & Lower Primary Education. All of the four options were included in this research.

##### 3.1.2 Research Design

In addition to the reading of different published sources, the research design of this study has been descriptive as it applied both quantitative and qualitative methods as systematic approaches that would allow the researchers to systematically collect and analyze data. The study is described in-depth on the role of ICT integration in improving the teaching and learning Mathematics with different methods such as direct observation and interaction through subject.

#### 3.2 Population and Sampling

The target population of this research was composed of 462 individuals. During this study, the researcher used simple random sampling for selecting the students while purposive sampling technique was used to select the tutors and IT manager (Alchemer, 2024). To guarantee a more precise and realistic assessment of the outcomes throughout the school, the sample was divided into groups to be considered in the analysis, the researcher used the cards to be chosen by the students to select participants from all classes in TTC Gacuba II. The following table shows the details.

**Table 1**

*Sample Size*

Target Population	Males	Females	Total	Sample size	Percentage
Students	206	252	458	82	95.3
Mathematics Tutors	3	0	3	3	3.5
IT manager	0	1	1	1	1.2
<b>Total</b>	<b>209</b>	<b>253</b>	<b>462</b>	<b>86</b>	<b>100</b>

According to the above table 1, the population of the study was composed of all 462 individuals including 458 students (206 boys and 252 girls), 3 male tutors of Mathematics and 1 female IT manager of TTC Gacuba II. The sample size of the study is 86 participants composed of 82 students, 3 tutors of Mathematics and 1 IT manager.

#### 3.3 Data Collection Tools

Apart from documentation, in conducting this study, the needed primary data were obtained via interviews and questionnaires administered to the concerned respondents. Questionnaires, interviews and observations were used to collect data from students, tutors and the school IT manager at TTC Gacuba II.

### 3.4 Data analysis and Presentation

All the collected data were analyzed by using an Excel sheet. Then, the quantitative data were presented in tables showing frequencies and percentages followed by some descriptions whereas the qualitative data were analyzed presented thematically.

## IV. FINDINGS & DISCUSSIONS

### 4.1 Response Rate

All the 86 sampled respondents were given either questionnaires and/or interviews, and no one failed to answer. Therefore, the respondents participated at 100% rate.

**Table 2**

*The Rate of Responses*

Response rate	Frequency	Percentage
Replied	86	100
Not replied	0	0
<b>Total</b>	86	100

### 4.2 ICT Tools Utilized by Mathematics Tutors in TTC Gacuba II Classrooms

On the utilization of ICT tools in teaching and learning Mathematics in TTC Gacuba II, the following table presents respondents' views on the usefulness of available ICT tools in enhancing the teaching and learning of Mathematics.

**Table 3**

*The Usefulness of ICT Tools Available in TTC Gacuba II in Enhancing the Teaching and Learning of Mathematics*

Available ICT Tools	Students	Percentage	Tutors and IT Manager	Percentage	Total	Percentage
Computers	80	97.6	4	100	84	97.7
Projectors	80	97.6	4	100	84	97.7
Internet	82	100	4	100	86	100
Flash disk and memory cards	79	96.3	3	75	83	96.5
Phones or tablets	36	43.9	2	50	38	44.2
YouTube videos	79	96.3	3	75	81	94.2
Printers	55	67.1	3	75	58	67.4
Scanners	14	17.1	1	25	15	17.4
Loudspeakers	26	31.7	2	50	28	32.5
CDs or DVDs	11	13.4	2	50	13	15.1
Microsoft offices (Word & Excel)	73	89	4	100	77	89.5

According to the table 3 above, it has been found computers are very useful and helpful in the given activities of Mathematics at the average of 97.7% as shared by all respondents. It also indicates that the usage of the projector by tutors of Mathematics and the students is at 97.7% useful and helpful. Flash disks and memory cards were at 96.5%, YouTube videos at 94.2% while the internet was ranked to be useful and helpful by 100%, the Word processing and Excel calculations at 89.5% and the printers at 67.4% of respondents. In addition, phones/tablets, loudspeakers scanners and CDs/DVDs were ranked useful at less than 50% of the respondents respectively. Hence, some of the stated tools function as the input devices while others are output devices that play a big role in the integration of ICT in improving teaching and learning Mathematics. On students' utilization of ICTs in the learning process, it has been found that searching on the internet was very useful and helpful for students to improve their mathematical learning process, downloading the materials, presentations and connecting the different electronic devices, and uploading their works. Therefore, referring to these findings, the results showed that the students are very interested in integrating ICT to improve their performance in learning and succeeding in Mathematics lessons.

### 4.3 Perception of Mathematics Tutors about the Use of ICT Tools

On Attitudes of tutors towards ICT tools as Mathematics teaching and learning at TTC Gacuba II, it has been found that all the tutors recognized that the computers, projector, and internet are useful and helpful at 100% (3 out of

3). It was also found that Microsoft Office (Word processing, Spreadsheet and PowerPoint) and Geogebra were useful and helpful at 66.7% (2 out of 3); and the use of email was 33.3% (1 out of 3) for each option, except not all. This shows that all the tutors of Mathematics at TTC Gacuba II have discovered the importance of ICT tools in teaching and learning Mathematics.

The study sought to find how the tutors were integrating ICTs in their lesson delivery, after observing how it had been done; thereafter, the researchers conducted interviews with the tutors that indicated that proper ICT integration in their teaching process has a good impact on the improvement of Mathematics subject, especially its performance can be at a high level. The following are the key responses.

The first interviewee responded: *“Computers and projectors could support the given duties to improve the teaching and learning of Mathematics at secondary school, but those tools are not sufficient”*.

The second interviewee replied: *“Modern software needs to be integrated into Mathematics subject so that to improve the teaching and learning Mathematics at secondary school can be at a high level”*.

The third interviewee responded: *“ICT integration in improving teaching and learning Mathematics for secondary schools builds the capacity of the students so it must be strengthened”*.

On the use of ICT tools in the mathematics classroom, it has been found that 100% of respondents integrated ICT tools in teaching and learning Mathematics so that performance can be increased. 100% of respondents reported that teachers prepare the lessons by using ICT in teaching and learning Mathematics to improve the participation of the students to be more active and productive. 66.7% of respondents showed that recognizing different tools leads to diverse thinking whereby the tutors noticed that ICT tools could help during the problem-solving process, the tutors became more intentional about monitoring students' thinking for integrating ICT tools in improving the teaching and learning Mathematics at secondary school. It was found that using YouTube videos was very useful and helpful at 96% when it was used regularly in the teaching and learning process because they gained explanations through watching, listening, writing, and reading. It was also found that to recognize the browsers to be used was at 79%, most of the participants showed that download was very useful and helpful at 89% while upload was at 75%, it was found that the discussion through the use of e-mails was useful and helpful at 64% because most of the participants were not aware with the virtual environment and sharing options through that platform.

The first interviewee responded: *“with the help of using e-mail and internet in the mathematical activities, they explore more by watching YouTube videos.”*

The second interviewee responded: *“downloading the files and discussing them so that they can extend their role beyond the classroom is very crucial”*.

#### 4.4 Proposed ICT Tools to be used in Improving Teaching and Learning Mathematics

On Proposing the ICT tools that might be used for improving Mathematics teaching and learning in secondary schools, according to Madhu & Satinder (2020), schools, teachers and learners of Mathematics at secondary school level are encouraged to use the proposed new ICT tools in addition to what they have been using to support for better understanding of mathematical concepts and visualizing mathematical problems. However, some of the software and applications require payment before accessing them. The following is the list of software and applications that can be used by Rwandan secondary schools.

**Mathematical Software: Matlab:** It is a free basic and online high-performance language that helps in numerical computing, matrix calculations, graphical representation, and in data analysis (MathWorks, 2023). **Math CAD:** It is a no-free software for data analysis, signal and picture processing, regression line analysis, equation solving, graphing and curve fitting, and performing matrix operations (Mathcad, 2023). **Mathematica:** It is a no-free and available online software that helps in number theory, graphing functions, geometric computation, data analysis, mathematical computation, algebraic computation, picture computation, and visualization (Wolfram Research, 2023). **Maple calculator** is software used for technical computing, data analysis, numerical computation, matrix computation, etc.; it is available online but is not free (Maple Calculator, 2023). **Graphmatica:** This is a free downloadable software for solving polar and parametric equations, and for creating graphs in Cartesian coordinates (Graphmatica, 2023). **Graphing Calculator 3D:** It is an online free software used in plotting inequalities, parametric, polar and cylindrical equations, etc. (Math3D, 2023). **Math Mechanics:** It is a free downloadable software for two and three-dimensional graphing, differentiation, and integration (Math Software, 2023). **Mathematica Player:** It is a free downloadable software that aids pupils in comprehending mathematical ideas more fully (Wolfram Research, 2023). **Graph Sketch:** This is an online free software utilized to draw graphs of various functions, such as parametric and polar functions, etc. (GraphSketch, 2023). **Yenka:** It is a no-free software developed to help students build mathematical models, model various science investigations, and develop circuits fast (Yenka, 2023). **Microsoft Mathematics:** It is free online and free downloadable software developed for resolving equations, creating two and three diagrams, and

solving algebraic mathematical problems (Microsoft, 2023) (Uptodown, 2023). **Math Editor**: It is a free online software and free download that facilitates in creating, saving, and editing equations (Informer, 2023). **Maxima**: It is free to download software for factoring polynomials, factoring numbers, reducing the complexity of trigonometric expressions, resolving equations and systems, displaying graphs in two and three dimensions, limits, differentiation, and integration (SOURCEFORCE, 2023). **Scilab**: This is a free download software for numerical computation, two and three-dimensional graphing, optimization problems, and simulation (Systèmes, 2023). **Qmentat**: It is a free download software used in studying and working through mathematical problems without a calculator, paper, or pen (QMENTAT, 2023). **Mental Math**: It is free online software for learning basic mathematical operations such as addition, subtraction, multiplication, and division (Math Trainer, 2023). **TalkingMath**: It is free to download software utilized to perform addition, subtraction, multiplication, and division on simple arithmetic problems with the support of audio (papaTsoftware, 2023). **Braina**: This is a no-free utilized to perform addition, subtraction, multiplication, and division on simple arithmetic problems. A student says the problem must be solved and gets the answer (Braina, 2023).

**Mobile Apps: MyScript Calculator**: It is a no-free application used to carry out a variety of fundamental mathematical operations, logarithms, trigonometry operations, and constants like pi and Euler's numbers (MyScript, 2023). **Evernote**: This is a free application that helps for preparing notes in electronic form (Evernote, 2023). **Kindle**: It is a library of millions of free e-books covering a range of subjects (Amazon Kindle, 2023). **Photomath**: It is a free application used to provide step-by-step solutions to various mathematical puzzles with just a picture (Photomath, 2023). **Geometry Pad**: It is a free application for learning geometric concepts like drawing geometric shapes, etc. (STEM, 2023). **SAT Math Trainer**: It is a free application designed for practicing various problems including record of the quizzes (Khanacademy, 2023). **DragonBox**: It is a free application for games that help students learn mathematics with fun (DragonBox, 2023). **Academy of Math**: It is a free application to increase pupils' general comprehension of various mathematical concepts through the use of evaluation tools and videos (APKPure, 2023). **Math Pentagon**: It is a free application to build geometric objects and study topics such as ratios, geometry, trigonometry, algebra, and statistics (BYJU'S, 2023). **MathsPlayground**: It is a collection of games related to mathematical concepts based on grades and topics (Global Digital Library, 2023).

#### 4.5 Discussion of Findings

As far as the results are concerned, this study's findings have been presented basing on its three research objectives which were: (a) to identify ICT tools utilized by Mathematics tutors in TTC Gacuba II classrooms, (b) to investigate the perception of Mathematics tutors with regards to the use of ICT tools in TTC Gacuba II and (c) to propose the ICT tools that might be used for improving teaching and learning Mathematics in secondary schools. Looking back to the restated objectives, we can confirm that the results for all the three have been presented.

Starting from the identification of ICT tools available and used by the Mathematics tutors of TTC Gacuba II, the key findings have proved that there pre-existed some ICT tools in the school with a certain level of their usage by the tutors. Those tools can be categorized into the highly and low useful. On one hand, the highly useful tools (rate is higher than 50%) include the computers, projectors, flash disks, YouTube videos, the internet, the Word processing and Excel sheet, and the printers according to the respondents. On the other hand, phones/tablets, printers, scanners, loudspeakers and CDs/DVDs were ranked useful at less than 50% of the respondents. According to Torres-Diaz et al. (2016), the learners who tend to use the ICT internet more for educational materials are less likely to fail their examinations and both summative and formative assignments. Therefore, there is no doubt that the tutors whose students use these existing tools will not only be motivated, but also they will perform better than when they do not use them. Looking back to the reason why some of the available tools are classified as of low usage, it is because some of them can be replaced by others such as the CDs/DVDs, which most of the time, are replaced by flash disks. Some other reasons might be associated with the elaborated policies such as the restriction of telephone usage in high school, which may lead to the low usage of phones/tablets as sometimes the tutors thought of their misuse by some students. The last category of tools of low usage includes scanners and loud speakers which are the tools mostly used by tutors in their lesson preparations, arranging information and delivering their lessons (Mpumuje 2024).

Basing on the perception of Mathematics tutors with regards to the use of ICT tools in TTC Gacuba II, the results generally revealed that their perception is positive. This is proved by the fact that all the tutors stated that the computers, projectors and internet are useful and helpful at 100%, Microsoft Offices (Word processing, Spreadsheet and PowerPoint) and Geogebra were useful and helpful at 66.7%, the use of email at 33.3% and other tools (flash disks, telephones and tablets, scanners and printers, and CDs/DVDs) as shown in the above findings were taken useful to them. This shows that generally, the tutors of Mathematics at TTC Gacuba II have discovered the importance of ICT tools in teaching and learning Mathematics. As the study sought to find how the tutors were integrating ICTs in their lesson delivery, after observing how it had been done, the interviews with them indicated that proper ICT



integration in their teaching process can have a good impact on the improvement of Mathematics subject, especially its performance at a high level. This is in line with Nteziyaremye et al. (2024) and (Dunn, 2002)'s research findings which also highlighted the importance of the teachers' positive attitude towards the implementation of any new school program as teachers remain fundamental to the successful integration of ICT in education (MINEDUC, 2016).

Lastly, on the proposition of additional ICT tools that might be useful in improving teaching and learning Mathematics in secondary schools, this study has listed and explained some additional software and applications sought to be used by trying to categorize them into free and/or requiring some payments. We, therefore, have based on the pre-existing ICT tools in TTC Gacuba II to suggest various mathematical software and mobile applications together with the links where they can be accessed. This viewpoint is in line with the MINEDUC's ICT in Education Policy (MINEDUC, 2016) that highlights the importance of the ICT resources being distributed in all levels of Education in Rwanda.

## V. CONCLUSIONS & RECOMMENDATIONS

### 5.1 Conclusions

In conclusion, this research has highlighted that the efficient utilization of ICT tools in the process of teaching and learning has a positive impact on students' academic performance and achievements. The integration of ICT tools into the teaching and learning process enhances the learning experience and further develops the students' problem-solving skills. Additionally, the effective use of ICT tools also serves as a source of motivation and generates an interest in learning Mathematics among students (Bature, 2016). Based on the study findings, the availability of ICT facilities and technical support were found to be significantly the factors of ICT integration for improving teaching and learning Mathematics. Using ICT tools in teaching and learning Mathematics can be beneficial to both students and teachers, but only if used correctly. Teachers must receive training in ICT teaching practices that have an impact on students' learning before they can fully reap the benefits of ICT tools in mathematics education. Additionally, by utilizing ICT as a tool, students gain a thorough comprehension of the many mathematical concepts and spend useful time formulating strategies for solving challenging problems. ICT is a tool that students can use to solve issues, create graphs, and make calculations. In secondary education, ICT integration facilitates communication between instructors and students while teaching and studying mathematics. ICT helps to improve teaching skills by enhancing innovative teaching and the effectiveness of the classroom. It also helps in improving professional development and educational management.

### 5.2 Recommendations

It is recommended to teachers to integrate ICT into education for influencing Mathematics performance as another alternative that would be used to resort to the traditional method of teaching and learning process (Gachinu, 2014). Therefore, schools must organize continuous professional development activities related to the use of ICT tools for improving the teaching and learning process within the schools. The schools must promote the culture of using online classes like Google Classrooms so as to strengthen the applications that have been acknowledged and to update the acquired skills. The school should avail and monitor the use of proposed ICT tools that did not exist at school in order to improve ICT integration in teaching Mathematics. Moreover, further study should be carried out at the other levels of education to valorize the role of ICT integration in improving teaching and learning Mathematics for those levels. Another study also could be carried out on the other subjects so as to validate the findings related to the improvements that are needed in the teaching and learning process.

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