JRIIE Journal of Research Innovation and Implications in Education
Center for Research Implications & Practice

Website:www.jriiejournal.com ISSN 2520-7504 (Online) Vol.6, Iss.3, 2022 (pp. 18 - 28)

Factors Constraining Effective Application of ICT in Teaching and Learning Mathematics in Nyanza District Secondary Schools, Rwanda

Martin Bazina & Dr. Olivier Habimana
College of Education, African Center of Excellence for Innovative Teaching and Learning Mathematics and Sciences, Kayonza, Rwanda
University of Rwanda
Email: martinbazina84m@gmail.com

Abstract: *The study's goal was to look into instructional and psychological factors constraining effective application of Information and Communication Technology (ICT) in teaching and learning mathematics. Qualitative method and grounded theory research design were used in this research. An open-ended questionnaire, a semi-structured interview, and classroom observation was used as data collection tools. The sample of 28 mathematics teachers and 25 students were research participants. The study used thematic analysis, inductive approach for data analysis. According to the study's findings, instructional factors (teaching techniques, ICT tools and mathematics content) was found to be the main factors that affect effectiveness of application in teaching and learning mathematics, mainly insufficiency and irrelevancy of ICT tools. The study also found that psychological factors (attitude, belief and self-confidence) toward use of ICT in teaching or learning mathematics depend on how instructional factors through sufficiency and relevancy of ICT tools in teaching and learning environment. Constructivism theory was adapted for this study throughout data collection and analysis. The study recommends that educational department on district level should reach out to schools to examine the problem of the inadequacy of available ICT tools and their insufficiency, and starting to find the way of solving this issue. Mathematics teachers should conduct their self-research on how ICT is integrated into mathematics teaching and motivate students to do so.*

Keywords: *Instructional & psychological factors, Teaching & Learning, ICT & Mathematics.*

How to cite this work (APA):

Bazina, M. & Habimana, O. (2022). Factors constraining effective application of ICT in teaching and learning Mathematics in Nyanza District Secondary Schools, Rwanda. *Journal of Research Innovation and Implications in Education*, *6*(3), 18 – 28.

1. Introduction

Roger Bacon, a 13th-century English Franciscan friar, philosopher, scientist, and scholar, said: *"Neglect of mathematics works injury to all knowledge since he who is ignorant of it cannot know the other sciences or the things of the world"* (Sunita, 2019 p.1). Mathematics plays an important and distinctive role in human communities as well as a strategic role in the growth of humanity as a whole. The ability to calculate, which is related to the power of technology and the ability to organize socially, shows the importance of mathematics in the development of a society (Sunita, 2019). Changes in our economic and social world, historical events and trends, and new advances in technology and science have been some of the causes that have driven the changing mathematics curriculum throughout the 20th century (Baskoro & Wijaya, 2015). One of the skills and education of the 21st century is tools for work (ICT and information literacy) (Erdem, 2020). Technology is an important part of teaching and learning mathematics; it impacts mathematics teaching and helps students to learn more effectively (Baskoro & Wijaya, 2015).

ICT refers to the dissemination, storage, and management of data using various recognized technological tools and their resources and has become one of the main pillars of our modern society (Das, 2019). The education sector is also considered ICT as important because it can be used to teach and learn mathematics and become productive for student success and teacher achievement. For instance, mathematical teaching and learning processes bring liveliness to the classroom environment. This vitality is evident where students and teachers can access study and course materials at any time and from any place (Das, 2019). In addition, Keong et al. (2005), found that 89.5% of mathematics teachers in Malaysia used basic ICT applications in their teaching, such as software, visuals and graphics, and online demonstrations serving as mathematics teaching tools. Another study in New Zealand showed that the integration of ICT into mathematics lessons affects positively student outcomes (Jackson, 2017).

Strong and significant knowledge of technology, pedagogy, and content, and their interrelationships, define teachers' creativity and effectiveness in developing and delivering new representations of mathematical content (Malubay & Daguplo, 2018). In order to deliver these new representations of mathematical content, ICT can be productive, as Shahadat (2012) in his research found that ICT has the ability to significantly improve the educational system in which mathematics is contained. However, developing countries are still far from reaping these benefits due to various obstacles. For example, the integration of new pedagogical technological tools at every level of the school system and the adaptation of new technological devices to curricula and classroom practices (Amy M. Johnson, Matthew E. Jacovina, Devin G. Russell, 2016). In relation to mathematics teaching and learning, a survey on barriers preventing the integration and adoption of ICT in mathematics education conducted in Malaysia identified six main barriers: lack of time in the school schedule for projects involving ICT, insufficient opportunities for teacher training for ICT projects , insufficient technical support for these projects, lack of knowledge about ways to integrate ICT to improve the curriculum, difficulties in integrating and using different ICT tools in a single lesson, and lack of resources at home to enable students to access the necessary teaching materials (Raman & Hamidah, 2014).

Das (2019) found ICT to be the most powerful tool for problem solving, conceptual development and critical thinking in mathematics. He also found that by using ICT as a tool, students spend productive time strategizing to solve complex problems and develop a deep understanding of the various mathematical topics such as doing calculations, drawing charts and running more challenging numbers. In addition, new mathematical structures are introduced and a new approach is taken to modernize mathematics teaching for greater benefit to students (Palamisamay, P. Saranavakumar, 2019). Even if ICT are needed in the teaching and learning of mathematics, Kaur (2019) in his research found that education in the modern technological society requires more information from teachers regarding ICT and the ability to use them in the teaching and learning process , particularly in their own subject areas. For instance, Malubay & Daguplo (2018) recommend strengthening the knowledge of mathematics teachers through regular participation in CPD related to the application of ICT in mathematics teaching and learning. In addition, teachers should not only be about the use of new technologies but also why and when to use them in transforming teaching and learning practices (Halai & Tennant, 2016, p. 69).

The results of Anyonyi (2013) on the study on factors limiting the use of ICT in secondary mathematics education in Nairobi found that 61.91% of mathematics teachers have no knowledge of ICT, indicating that the most of them do not have the necessary computer skills to create ICT-integrated lesson plans for the classroom. Another study at Nairobi County Secondary Schools on opportunities and challenges in integrating ICT into mathematics teaching and learning showed that teachers face major challenges such as developing their own technological skills and knowledge, and self-training in the use of ICT in their mathematics lessons (Amuko et al., 2015). Uworwabayeho (2009), in his research on the case of Rwanda, found that teachers and learners value the use of ICT in teaching and learning mathematics. He also found that the participation in learning in computer-aided lessons found to be very high compared to traditional lessons without computer. Therefore, ICT is considered important and can be useful to improve mathematics teaching and learning. Even though ICT can be an effective tool for teaching mathematics, there are still challenges that can hamper its effectiveness, some of which are mentioned above.
The study attempted to achieve the goal by focusing on the following research questions:

(a) What are the instructional factors that constrain the effective application of ICT in the teaching and learning of mathematics?
(b) What are the psychological factors that constrain the effective application of ICT in teaching and learning of mathematics?
(c) What are the most powerful factors that constrain the effective application of ICT in teaching and learning of mathematics?

1.1 Statement of the problem

The Rwandan government has identified ICT as a crucial tool for economic transformation, with education playing a key role in achieving this goal (Republic of Rwanda, 2000). A number of projects have been launched to provide basic ICT infrastructure and computers in schools (EdQual, 2010). The Rwandan curriculum framework

recommends the use of ICT to improve the quality of education in all subjects at all levels (MINEDUC, 2015), where the mathematics curricula state that as new technologies have had a dramatic impact on all aspects of life, wherever possible, mathematics learners should gain experience with a range of ICT devices and applications. Each lesson also requires the use of digital technology or computers during or after mathematics lessons (REB, 2015).

The Rwandan government has identified ICT as a crucial tool for economic transformation, with education playing a key role in achieving this goal (Republic of Rwanda, 2000). A number of projects have been launched to provide basic ICT infrastructure and computers in schools (EdQual, 2010). The Rwandan curriculum framework recommends the use of ICT to improve the quality of education in all subjects at all levels (MINEDUC, 2015) where in mathematics syllabi, it is said that, as new technologies have had a dramatic impact on all aspects of life, wherever possible in mathematics, learners should gain experience of a range of ICT equipment and applications. For each unit, digital technology or computers are also required to be used during or after mathematics class (REB, 2015).

In mathematics teaching and learning, ICT plays an important role in connecting teachers and students. The study by Umugiraneza et al. (2018) on the use, access, and integration of technology by mathematics teachers in teaching and learning mathematics found that about 80% of participants expressed a positive view that the use of technology improves learners' understanding of mathematics. Various studies and practices show that ICT is the best tool for assessing student learning. For instance, ICT is increasingly used successfully in teaching, learning, and assessment. ICT is seen as a powerful tool for educational change and reform. A number of previous studies have shown that appropriate use of ICT can increase the quality of education and link learning to real-life situations (Fu, 2013).

However, most teachers and students face several obstacles to the implementation of ICT in teaching and learning mathematics. In the study conducted in South Kalimantan, Indonesia, indicated that the barriers faced by mathematics teachers in the digital age when implementing technology in mathematics teaching and learning included: math learning materials that were less suited to the use of technology; School facilities, infrastructure and support were inadequate for the use of technology in teaching and learning; the level of teacher skills in using technology in teaching and learning mathematics. Factors that have influenced the occurrence of these barriers include teachers' assessments and viewpoints of the effectiveness of using technology in teaching and learning mathematics in the classroom; unequal access to educational services between schools in towns and villages; and lack of training and information for teachers on the use of technology in mathematics education (Muhazir & Retnawati, 2020).

It then looks at some case studies from Rwanda using ICT in mathematics teaching, demonstrating how ICT can be useful in a low-income context and drawing implications for how this important area of education could be further developed (Halai & Tennant, 2016). In addition, ICT plays an important role in mathematics education, as research shows that with teachers' willingness to adapt their pedagogical approaches, the use of new technologies such as Dynamic Geometry Software (DGS) could improve mathematics teaching and learning (Uworwabayeho, 2009). There is also evidence that the presence and use of ICT in Rwandan schools in teaching and learning mathematics is still minimal. Numerous challenges such as a shortage of teachers trained to use ICT in the teaching and learning process and a gap in the implementation of digital competences and their operational plan (Mugiraneza, 2021). Despite this, one of the aims of the Rwandan ICT Education Policy Statement is to use ICT as a tool to improve the quality of education in all subjects, including mathematics (MINEDUC, 2016, p. 10). Against this goal, which is silent in the literature, this study aims to investigate what factors limit the effective use of ICT in teaching and learning mathematics in secondary schools in Nyanza District, Southern Province, Rwanda.

2. Literature Review

Technology is and will remain an important part of our daily lives and is increasingly being used as a teaching tool in a variety of ways (Tishkovskaya & Lancaster, 2012). The teaching strategies of teachers determine the success of technology integration in the teaching and learning process. It also depends on how teachers select and handle digital resources in their classroom activities and what classroom tactics they use (Mailizar & Fan, 2020). In addition, Hossein-mohand & Melchor (2020) found that a number of factors, including the type and amount of technical resources available, influence the incorporation of ICT into teaching approaches. Despite the fact that technology is crucial in secondary schools, the majority of teachers have a low or intermediate level of digital competence. However, perceptions, attitudes and methodical handling of ICT as well as usage that differs according to gender, age and teaching experience must be taken into account.

2.1 ICT in Rwandan secondary school mathematics curriculum

The policy, which guided the development of the curriculum framework in Rwanda for integrating information and communication technology into education, establishes principles, goals and strategies to control and strengthen the innovative and cost-effective power of world-class educational technology tools

(MINEDUC, 2015). It also embraces new categories of learners, fosters communication and collaborative skills, and builds the capacity of everyone involved in the delivery of education to develop a competent and relevant ICT professional (MINEDUC, 2015). Furthermore, in the Rwandan secondary school mathematics curriculum, teachers are encouraged to use ICT in teaching and learning mathematics (REB, 2015). The mathematics teaching methodology outlined in Rwanda's competency-based curriculum, the Secondary School Mathematics Curricula (REB, 2015), requires the incorporation of ICT into the teaching and learning process, as this makes the subject exciting and stimulating for both learners and teachers power. Das (2019) found in his research that the use of ICT in mathematics has more benefits for learners' content comprehension and introduces a new dimension of learning and teaching that includes the use of the internet and mathematics software.

2.2 Instructional factors and ICT in teaching and learning of mathematics

Information and communication technology is seen as an essential means of promoting new teaching and learning methods (Pierre, D.J. & Andala, 2020). The intersection of technology and education has the potential to transform the way we think and practice. For example, teachers can use technology in a variety of ways, including simple exercises and practice tasks (Koehler & Mishra, 2006). When teaching mathematics, a strong and meaningful knowledge of technology, pedagogy and content and their interrelationships define teachers' creativity and effectiveness in developing and delivering new forms of representation of mathematical content (Malubay & Daguplo, 2018). As part of mathematics learning, students need to build their own understanding of each concept of mathematics to create their essential mental structures and higher order of thought (Lessani et al., 2016). Therefore, ICT should be used in constructive learning processes as it stimulates and facilitates higher-level thinking of learners instead of just conveying more information (Qi & Jianwei, 2000). Unfortunately, the teacher's knowledge of using mathematics software is not the only criterion for integrating ICT into mathematics teaching, as there are other factors such as a solid pedagogical understanding of integration into mathematics teaching (Keong et al., 2005). For example, Jones (2004), cited in (Keong et al., 2005) found that there were several barriers to integrating ICT into mathematics education. These limitations included a lack of access to resources, time for integration, adequate training, and technical issues in using the software, and a lack of face-to-face access during lesson preparation. While, in Rwanda, EdQual (2010) research found that the support provided by the annual workshops on the use of ICT in the classroom was key to enabling teachers to use available technology for science and mathematics teaching.

2.3 Psychological factors and ICT in teaching and learning of mathematics

A positive attitude is considered to be one of the most valuable tools in learning mathematics, since any task attempted is strongly influenced by one's attitude towards it (Tahir & Bakar, 2009). Furthermore, ICT integration in education strongly depends on teachers' ICT literacy, skills and positive attitude (Ndayambaje & Ngendahayo, 2014). Also Sabzian and Gilakjani (2013), cited in Umugiraneza et al. (2018) argue that the lack of computer instruction often results in teachers having low confidence when initiating computer activities. Teachers' beliefs about teaching and learning play an important role in their decisions about how to deliver the content (Umugiraneza et al., 2018). Furthermore, with technological breakthroughs and practices advancing, Ndayambaje & Ngendahayo (2014) found that given current ICT trends, teaching with ICT requires applicable skills and confidence that can only be achieved if teachers take a positive attitude towards it. Brown et al. (2005) also found that there are significant disparities between schools and within mathematics departments, and that teachers still lack confidence in the use of ICT in their classrooms. EdQual (2010) research shows that teachers with relatively little external support through workshops gain confidence in using existing ICT tools to design innovative environments for teaching mathematics.

2.4 Theoretical framework

The theoretical framework used to examine this study is Grounded Theory. Grounded theory was first introduced by Glaser and Strauss in their book *The Discovery of Grounded Theory (1967)*. Strauss & Corbin (1994) describe grounded theory as a set of relationships that offer a plausible explanation of the phenomenon under study, namely the theory based on data that are systematically collected and analyzed. In grounded theory studies, theory emerges from the systematic investigation of the phenomenon. In the process, data is collected in parallel with the formation of theories. Furthermore, the grounded theory approach includes the possibility of developing or adapting existing theoretical statements from data, which should increase the researchers' confidence in the area of theorizing (Shannak & Aldhmour, 2009). Therefore, in this study the constructivism theory was adopted on the basis of the collected data.

During this journey of building knowledge and experience, and creating an enabling environment for the use of ICT in the effective teaching and learning of mathematics, there are still factors that limit this effectiveness, as the results of this study show. ICT should be used to enhance learners' social interaction, which is

another critical perspective of knowledge construction. In addition, an educational reform based on constructivism aims to make progress over traditional education, which still has its own advantages but faces major challenges (Qi & Jianwei, 2000). Therefore, significance of constructivist context can provide an important direction for successful using knew knowledge about ICT in teaching and learning mathematics to overcome the challenge in traditional mathematics instruction. This theory was adapted as relevant one for this study because by using technology in the constructivist classroom, teachers will engage students with the lesson more actively, work collaboratively and develop more complex thinking skills. Constructivists believe that technology should be used by the students as a tool to explore problem solutions and acquire new information and knowledge (Ayse, 2018).

3. Methodology

This section intends to discuss research design, population and sampling, instruments for data collection, data analysis method, trustworthiness of the study and ethical considerations used in the study.

3.1Research Design

The research used qualitative method and grounded theory design with interpretivism paradigm was used to collect data. Inductive thematic analysis was used to analyse data. However, in order to address the study issue, the following steps were taken:

Filling open ended questionnaire

For questionnaire, there were three questions related to instruction factors (mathematics content, methodology, and ICT tools) toward using ICT in teaching mathematics, and two questions related to psychological factors (attitude, belief and level of confidence) toward using ICT in teaching mathematics.

Participating in semi-structure interview schedule

For semi-structure interview schedule, there were three questions related to instructional factors (mathematics content, methodology used for teaching mathematics, and ICT tools) toward using ICT in learning mathematics, and two questions related to psychological factors (attitude, belief and level of confidence) toward using ICT in learning mathematics.

Conducting classroom observation checklist

For classroom observation checklist, there were four main sections. First section for looking about instructional factors (mathematics content, methodology and ICT tools used) toward teaching and learning mathematics.

3.2 Population and Sampling

This research was conducted in Nyanza District at the secondary school level and was of interest to all senior three and six students and mathematics teachers of that district as a study population.
In this study, purposeful sampling was used to select ten secondary schools in the Nyanza District. Due to time constraints and COVID-19 pandemic, not all teachers and students could participate in the research. Therefore, 28 mathematics teachers and 25 students from each selected school were specifically selected to participate in completing the open-ended questionnaire (for mathematics teachers) and in a semi-structured face-to-face interview for students. The samples are shown in Table 1 below:

Table 1: Samples of Schools, mathematics teachers and students in Nyanza District

Number of Schools	Participants	Number of participants	
Ten secondary schools.	Mathematics teachers	Male	19
		Female	9
	Total		28
	Students	Male	15
		Female	10
	Total		25

3.3 Data analysis method

Methods of data analysis were chosen to ensure the trustworthiness and reliability of this study. The nature of this study, according to the information required about the

phenomena studied and the types of all data collected, were influenced by the data analysis. In this research, inductive thematic analysis was applied in analyzing data. Thematic analysis is a method for systematically identifying, organizing, and providing insight into patterns of meaning (themes) in a data set. By focusing on the meaning of a dataset, thematic analysis allows the researcher to see and understand collective or shared meanings and experiences (Kiger & Varpio, 2020). This method was used to analyze collected information in the form of text from the open-ended questionnaire, semi-structured interview transcripts, and information from notes taken during classroom observation to achieve the objective of this research and to answer research questions.

Coding and themes

Patton (1980) said that, inductive analysis is the main technique used in the grounded theory method. Inductive analysis means that the patterns, themes, and categories of analysis come from the data; they arise from the data rather than being imposed on them prior to data collection and analysis. According to Morse and Field (1995) a grounded theory is generated by themes, and themes emerge from the data during analysis, capturing the essence of meaning or experience drawn from varied situations and contexts. Thematic analysis, which involves finding and identifying common themes, through interview transcripts and responses to open-ended questions, codes were identified and from which the themes are derived. This study has three main themes, which are discussed in the next chapter. These themes are in Table 2 below:

Table 2. Coding and theming

Codes	Sub-themes	Themes
• Mathematics content • Teaching methodology • ICT resources	• Teaching strategies • Mathematics and new technology	**Theme 1:** ICT resources and teaching mathematics.
• Attitude • belief toward new technology • Level of confidence	• Attitude and belief toward ICT • Level of confidence toward ICT	**Theme 2:** Teachers' and students' insight toward use of ICT in mathematics

3.4 Trustworthiness of the study.

To maintain quality standards while conducting this research, considering participants' responses and being deeply immersed in the research process was taken into consideration. It was also necessary to explore data by using a well-designed face to face interview guide, open questionnaire and classroom observation checklist. Trustworthiness was achieved through credibility, transferability, dependability, Confirmability, flexibility, and authenticity (Korstjens & Moser, 2018). In this study, the research findings represented plausible information drawn from the participants' original data and was a correct interpretation of the participants' original views. Participants' evaluation of the findings, interpretation, and recommendation of this study was supported by the data as received from participants. Reflexivity was presented through critical self-reflection about oneself as a researcher and the research relationship (relationship to the respondent, and how the relationship affected participant's answers to the questions). This study was also concerned with how far research methodology and data or information, gathered, are reliable or true through being careful about the fair answers from the respondents.

3.5 Ethical consideration

This study examined the factors (instructional, demographic and psychological) that limit the effective use of ICT in mathematics teaching and learning at the secondary school level. Mathematics teachers and students participated voluntarily in this research, trusting the rules and regulations that allowed the researchers to deliver open messages and deep conversations. The researcher informed respondents in writing (consent form), electronically and orally about the characteristics of this study and their responsibilities as contributors. Safeguards were implemented during the study to preserve the identities of the participants and their voices. All confidential guidelines and measures were followed to ensure the protection of each participant in this study. Before conducting this study, ethical clearance was obtained from the Directorate of Research and Innovation at the University of Rwanda, College of education.

4. Results and Discussion

This study showed factors that constrain effective application of ICT in teaching and learning mathematics. Valuing the preceding study and the scholars' works describing this phenomenon bounded the researcher's interest in exploring specifically instructional and

psychological factors. Studying about these factors showed that, even if its application in teaching and learning is helpful, there is still factors that can affect its effectiveness, especially in teaching and learning mathematics. Qualitative method with Grounded Theory Design, inductive thematic analysis method was used to collect and analyze data. The findings are the synthesis of the participants' understanding and viewpoints on the issue under investigation. The researcher constructed the study background based on four fundamental questions to investigate the instructional and psychological factors that limit effective application of ICT in teaching and learning mathematics:

(a) What are the instructional factors that constrain the effective application of ICT in the teaching and learning of mathematics?
(b) What are the psychological factors that constrain the effective application of ICT in teaching and learning of mathematics?
(c) What are the most powerful factors that constrain the effective application of ICT in teaching and learning of mathematics?

Findings and interpretation

This section presents the key shared thoughts of the respondents. It shows the most common participants' understanding about factors constraining effective application of ICT in teaching and learning mathematics. This includes some shared lived experiences and personal viewpoints that respondents credited to the phenomena being studied. As the research questions reflect the researcher's ability to interpret the participants 'experience and viewpoints, the participants shared their experience and understanding through the semi-structured interviews, open-ended questionnaires which were supported by classroom observations. Researcher paid careful attention about participants' understanding and opinions to the phenomenon under study. The participants presented in their own words, their understanding, insights, and opinions in the whole research. The respondents 'responses and classroom observation notes are based on research questions. All research instruments that used in this study was designed based on research questions as it is explained in the section of data collection method. There is questionnaire for mathematics teachers that composed by ten open ended questions, semi-structured interview for students that composed by nine open ended questions, and classroom observation checklist with four main sections based on instructional factors, psychological factors, and general conclusion for whole observation.

In this study, there were mathematics teachers and students as participants. The results from each of them was analyzed in a complementary manner to answer research questions and was not analyzed comparatively as that was not the aim of the study. For each research question there was common opinions from the most participants. After reading through interview transcripts, questionnaire responses, and classroom observation notes, codes and themes were created to draw general conclusions about the phenomena under study by answering research questions.

What are the instructional factors that constrain the effective application of ICT in the teaching and learning of mathematics?

One of the participants as many others said that, every unit of mathematics can be taught using ICT. The challenge is that some mathematics teachers don't know how to use ICT tools, and important mathematics software that are not available. He added that, due to the lack of enough ICT tools affect methodology in terms of time consuming for lesson with ICT integrated. He concludes by saying that, the effectiveness of using ICT is limited due to some important mathematics software which are not updated or available.

Another participant said that mathematics content fit with ICT integration at fifty percent because of limited ICT resources. This insufficiency also affects methodology was used during teaching and learning mathematics. She concluded by saying that, the available ICT tools are helpful at high level and there is no challenge when they are used in mathematics class. Therefore, the effectiveness of using ICT is depend on the availability and relevancy of ICT tools.

What are the psychological factors that constrain the effective application of ICT in teaching and learning of mathematics?

One of participants as many others said that, he has positive attitude and belief toward use of ICT in teaching mathematics and he always enjoys its importance in teaching. He added that, this positive attitude helps him to be confident while using ICT in mathematics lesson or conducting research himself. He concludes by saying that, this positive attitude, belief and being confident increases effectiveness of using ICT in mathematics class and the challenge remains as lack of enough ICT tools.

Another participant said that she has positive attitude toward use of ICT in learning mathematics because it is helpful even in real life. She added that her level of confidence is in middle range because she does not have enough skills about using ICT tools due lack of enough ICT resources. She concludes by saying that, the effectiveness in using ICT in mathematics depends on not only attitude and being confident but also the ability to use it.

What are the most powerful factors that constrain the effective application of ICT in teaching and learning of mathematics?

Data collected from semi-structured interviews, open-ended questionnaires and classroom observations, as well as insights into instructional factors (math content, teaching methodology and ICT tools) show that all mathematics content can be taught using ICT. It also showed that the methodology used in traditional teaching should be improved when mathematics teaching integrates ICT. Regarding ICT tools used in teaching and learning mathematics, the results show that they are still insufficient, some of the tools available are not updated or relevant, and some teachers and students do not have sufficient skills to use the available tools resulted from insufficient or irrelevant of ICT resources.

Psychological factors (attitude, belief and confidence in using ICT in mathematics teaching and learning) indicate that attitude, belief and level of confidence in relation to the effectiveness of using ICT in mathematics teaching and learning contribute positively, depending on the availability and effectiveness of ICT tools. Most participants have a positive attitude, good faith and a high level of trust in the available ICT tools at their school, but the challenge remains their inadequacy or incompatibility.

Therefore, among those discussed factors, it was found that instructional factors are the most powerful factors that are limiting the effective use of ICT in mathematics teaching and learning due to insufficiency or irrelevant ICT tools. In teaching and learning mathematics, there is no formal method that teaches how and when to teach and learn mathematics using ICT tools. As stated by most of the participants, they acquired their knowledge about the use of ICT in teaching and learning mathematics through CPD or their self-research. The commitment of the participants shows that when ICT tools are sufficient and relevant for each school, psychological factors cannot affect the effectiveness of using ICT in teaching and learning mathematics, since every student and teacher has all the basic and relevant knowledge and skills. Obviously, if teachers cannot access ICT resources, then they will not use them and will affect attitude, belief and self-confidence toward use of ICT in teaching and learning of mathematics.

Discussion on findings

Theme 1: Teaching mathematics and ICT resources

This theme is based on the participants' opinions related to the first research question. The findings from interview protocols and answers to open questions are supported by notes from observations of lessons. Most respondents indicated that the effectiveness of ICT use in mathematics teaching is hampered by not having enough ICT tools (hard or soft). They also added that some of the available ICT tools are not updated or do not match the mathematics content to be taught. Therefore, neither teaching techniques nor mathematics content can affect the effectiveness of using ICT in mathematics teaching if each class is equipped with appropriate ICT tools for which students and teachers can acquire and improve their ICT skills used in teaching or learning mathematics, and in other real life situation. Crisan et al. (2007) pointed at factors related to technological tools, the system, and teachers' preparation programs as one influencing the integration of ICT in the classrooms where access to ICT infrastructure and resources in schools is a necessary condition to the integration of ICT in education.

Theme 2: Teachers and student insight toward use of ICT in mathematics

This theme was created using different respondents' perspectives and was based on second research question. All respondents showed a positive attitude and belief in the use of ICT in teaching or learning mathematics, recognizing its importance for doing mathematics anytime and anywhere. Most of participants indicated that they do not feel safe using ICT tools because of their insufficiency. They add that using traditional methods in teaching or learning mathematics is not their choice, but it depends on a lack of sufficient ICT resources where they only used to use scientific calculators, their connected smartphones or visit not well-equipped smart classroom. Using ICT in this unfavorable situation can reduce students' or mathematics teachers' confidence while using ICT, even they have positive attitudes and beliefs toward the new technology. Even if, 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 into teaching and learning processes (Demirci, 2009). In contrast, teachers' positive feelings towards the use of ICT in mathematics lessons indicated that they would use ICT in their actual lessons if the relevant conditions are met, like rich workshops and an appropriate technological infrastructure (Baya'a & Daher, 2013).

5. Conclusion and Recommendations

5.1 Conclusion

This research aimed at examining factors limiting the effective use of ICT in teaching and learning mathematics in ten selected secondary schools of Nyanza District. The sample of 53 participants (mathematics teachers and students) was purposively selected to convey opinions and viewpoints through semi-structured interviews or response to an open-ended questionnaire supported by classroom observation. The obtained primary data was used to answer research questions of this research

The findings of this study show that while there can be many factors that affect the effectiveness of using ICT in teaching and learning mathematics, there is the most powerful among them. These are instructional factors that include teaching methodology, mathematics content to be taught and teaching materials (ICT tools for this study). Regarding the themes discussed above, which involve instructional and psychological factors, researchers analyzing participants' opinions, perspectives, feelings, and classroom observation notes indicated that demographic and psychological factors depend on instructional factors.

The dependence of psychological factors on instructional factors was also observed through respondents' statements on their attitudes, beliefs and self-confidence regarding the use of ICT in teaching or learning mathematics. It was found that all participants have a positive attitude and belief towards the use of ICT in teaching and learning mathematics because they find them relevant and helpful when given the opportunity to use them. It was also found that the problem of lack of confidence in using ICT in teaching or learning mathematics depends on lack of experience and sufficient skills in use. Experience and skills in using ICT when teaching or learning mathematics depend on the availability and relevance of ICT tools in the teaching and learning environment. For instance, effective adoption and integration of ICT into teaching in schools depends mainly on the availability and accessibility of ICT resources such as hardware, software (Plomp & Voogt, 2009). Therefore, the effectiveness of using ICT in mathematics also depends on its frequent use, which will help develop students' and teachers' attitudes, beliefs and levels of trust towards ICT tools.

5.2 Recommendations

The study recommends that educational department on district level should reach out to schools to examine the problem of the inadequacy of available ICT tools and their insufficiency, and starting to find the way of solving this issue. Mathematics teachers should conduct their self-research on how ICT is integrated into mathematics teaching and motivate students to do so.

References

Amuko, S., Miheso, M., & Ndeuthi, S. (2015). Opportunities and Challenges : Integration of ICT in Teaching and Learning Mathematics in Secondary Schools , Nairobi , Kenya. *Journal of Education and Practice*, *6*(24), 1–7.

Amy M. Johnson, Matthew E. Jacovina, Devin G. Russell, and C. M. S. (2016). Challenges and solutions when using technologies in the classroom. *Adaptive Educational Technologies for Literacy Instruction*, 13–29.

Anyonyi, K. E. (2013). Factors limiting the use of ICT in teaching mathematics at secondary level,Kenya International Conference On Innovation Perspectives. *International Conference On Innovation Perspectives, Psychology And Social Studies*, 1–12.

Ayse, D. I. (2018). Use of technology in constructivist approach. *Educational Research and Reviews*, *13*(21), 704–711.

Baskoro, E. T., & Wijaya, K. (2015). Mathematics in the 21st Century. *6th World Conference, Lahore, March 2013*, *98*, 11–18. http://link.springer.com/10.1007/978-3-0348-0859-0

Baya'a, N., & Daher, W. (2013). Mathematics teachers' readiness to integrate ICT in the classroom. *International Journal of Emerging Technologies in Learning*, *8*(1), 46–52.

Brown, G., Cadman, K., Cain, D., Clark-Jeavons, A., Fentem, R., Foster, A., Jones, K., Oldknow, A., Taylor, R., & Wright, D. (2005). *ICT and mathematics: A guide to learning and teaching mathematics*. http://eprints.soton.ac.uk/41376/

Crisan, C., Lerman, S., & Winbourne, P. (2007). Mathematics and ICT: A framework for conceptualising secondary school mathematics teachers' classroom practices. *Technology, Pedagogy and Education*, *16*(1), 21–39.

Das, K. (2019). Role of ICT for better Mathematics Teaching. *Shanlax International Journal of Education*, *7*(4), 19–28.

Demirci, A. (2009). How do Teachers Approach New Technologies: Geography Teachers' Attitudes towards Geographic Information Systems (GIS). *European Journal of Educational Studies*, *1*(1), 43–53.

EdQual. (2010). *Using ICT to Support Science and Mathematics Education in Rwanda Teacher education key to quality education with ICT* (3).

Erdem, C. (2020). Introduction to 21st century. In *Cambridge Scholars Publishing* (October 2019).

Fu, J. S. (2013). ICT in Education : A Critical Literature Review and Its Implications. *International Journal of Education and Development Using Information and Communication Technology*, *9*(1), 112–125.

Halai, A., & Tennant, G. (2016). *Mathematics Education in East Africa, Towards Harmonization and Enhancement of Education Quality* (A. H. · G.

Tennant (ed.)).

Hossein-mohand, H., & Melchor, G. (2020). Mathematics Teachers ' Perceptions of the Introduction of ICT : The Relationship between Motivation and Use in the Teaching Function. *Https://Www.Mdpi.Com/Journal/Mathematics*, *8*(2158), 1–17.

Jackson, M. (2017). Integration of ICT in the Mathematics Classroom. *Journal of Initial Teacher Inquiry*, *3*(1), 90–93.

Kaur, M. (2019). ICT in teacher education. *Bhartiyam International Journal of Education & Research*, *7*(3), 571–574.

Keong, C., Horani, S., & Daniel, J. (2005). A study on the use of ICT in mathematics teaching. *Malaysian Online Journal of Instructional Technology*, *2*(3), 43–51.

Khan, S. H., Hasan, M., & Clement, C. K. (2012). Barriers to the introduction of ICT into education in developing countries: the example of Bangladesh. *International Journal of Instruction*, *5*(2), 1308–1470.

Kiger, M. E., & Varpio, L. (2020). Thematic analysis of qualitative data: Amee Guide No. 131. *International Journal of Education in the Health Sciences*, *42*(8), 846–854. https://doi.org/10.1080/0142159X.2020.1755030

Koehler, M. J., & Mishra, P. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record*, *108*(6), 1017–1054.

Korstjens, I., & Moser, A. (2018). Series : Practical guidance to qualitative research . Part 4 : Trustworthiness and publishing. *European Journal of General Practice*, *24*(1), 120–124.

Lessani, A., Suraya, A., Yunus, M., Abu Bakar, K., & Khameneh, A. Z. (2016). Comparison of Learning Theories in Mathematics Teaching Methods. *Fourth 21st CAF Conference in Harvard*, *9*(1), 165–174.

Mailizar, M., & Fan, L. (2020). Examining Indonesian secondary school mathematics teachers' instructional practice in the integration of technology. *Universal Journal of Educational Research*, *8*(10), 4692–4699.

Malubay, J., & Daguplo, M. S. (2018). Characterizing mathematics teachers' Technological Pedagogical Content Knowledge. *European Journal of Education Studies*, *4*(1), 199–219.

MINEDUC. (2015). *Competence Based Curriculum: Curriculum framework pre-primary to upper secondary, Kigali, Rwanda.* Rwanda Education Board.

MINEDUC. (2016). *Rwanda ICT in Education Policy April 2016*.

Mugiraneza, J. P. (2021). Digitalization in Teaching and Education in Rwanda. In *The Report*. https://www.ilo.org.publication.wcsm-783668

Muhazir, A., & Retnawati, H. (2020). The teachers' obstacles in implementing technology in mathematics learning classes in the digital era. *Journal of Physics: Conference Series*, *1511*(1), 1–11.

Ndayambaje, I., & Ngendahayo, E. (2014). The use of computer based instructions to enhance Rwandan Secondary School Teachers' ICT competency and continuous professional development. *Rwandan Journal of Education*, *2*(2), 56–70.

Palamisamay, P. Saranavakumar, A. (2019). Role of Ict in Teaching and Learning. *Psikologi Perkembangan*, *7*(October 2013), 1–224.

Pierre, D. J. & Andala, H. O. (2020). Information and Communication Technology (ICT) Integration and Teachers' Classroom Pedagogy in Selected Secondary Schools in Nyanza DistrictRwanda. *Journal of Education*, *3*(3), 1–20.

Plomp, T., & Voogt, J. (2009). Pedagogical practices and ICT use around the world : Findings from the IEA international comparative study SITES2006. *Educ Inf Technol*, *14*, 285–292.

Qi, C., & Jianwei, Z. (2000). Using ICT to support constructive learning. In *Communications and Networking in Education* (January 1999, pp. 231–241).

Raman, K. &, & Hamidah, Y. (2014). Barriers Teachers Face in Integrating ICT during English Lessons: A Case Study. *Malaysian Online Journal of Educational Technology*, *2*(3), 11–19.

REB. (2015). *Rwandan mathematics syllabus for Advanced Level S4-S6.* Rwanda Education Board.

Republic of Rwanda. (2000). *Planning Rwanda Vision 2020. July 2000*, 30.

Shannak, R. O., & Aldhmour, F. M. (2009). Grounded theory as a methodology for theory generation in information systems research. *European Journal of Economics, Finance and Administrative Sciences*,

15, 32–50.

Strauss, A. & Corbin, J. (1994). Grounded theory methodology. In *USA, Sage publications.*

Sunita, Y. (2019). Role of Mathematics in the development of society. *International Journal of Research and Analytical Reviews (IJRAR)*, *6*(4), 295–298.

Tahir, I. M., & Bakar, N. M. A. (2009). Influence of Demographic Factors on Students' Beliefs in Learning Mathematics. *International Education Studies*, *2*(3), 120–126.

Tishkovskaya, S., & Lancaster, G. A. (2012). Statistical education in the 21st century: A review of challenges, teaching innovations and strategies for reform. *Journal of Statistics Education*, *20*(2), 1–56.

Umugiraneza, O., Bansilal, S., & North, D. (2018). Exploring teachers' use of technology in teaching and learning mathematics in KwaZulu-Natal schools. *Pythagoras*, *39*(1), 1–13.

Uworwabayeho, A. (2009). Teachers' innovative change within countrywide reform: A case study in Rwanda. *Journal of Mathematics Teacher Education*, *12*(5), 315–324.