INVESTIGATION OF TEACHERS' COMPETENCY ON USING ICT FOR TEACHING AND LEARNING MATHEMATICS AND SCIENCE SUBJECTS IN TANZANIAN SECONDARY SCHOOLS

Research article

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Abstract

This study focused on investigating teachers' competence on using ICT in teaching and learning mathematics and science subjects in secondary schools in Morogoro municipality. The research employed a quantitative method with the use of the descriptive design. The study had objectives that are to examine the teacher's ability to use the ICT tools, to show the relationship between the ICT tools and students' performance and to find out the challenges that teachers face during the use of ICT in teaching and learning process. The study used a sample of two secondary schools of which 35 teachers were selected from each school making a total of 70 respondents, whereby the questionnaires were used to collect data and the data were analyzed using the SPSS method. It was found that many teachers have the ability to use the ICT tools in teaching, and that there is a significant relationship between teacher competency in the use of ICT in teaching and the students' academic performance. It was also found that teachers face some challenges during the use of ICT tools in teaching including the poor infrastructure, the lack of expertise and capital problems. It was also found that the ways of overcoming them include improving the infrastructure, use of printed media as an alternative to the ICT tools as well as developing consistency of teachers. The study also recommends that the Ministry of Education, science and technology should ensure that all teachers train in ICT by introducing compulsory ICT courses to create the innovative model for teachers, sufficient facilities and resources should be provided and also professional development programs should be organized for teachers in order to develop ICT knowledge and competence.

Keywords: Teaching and learning, mathematics and sciences, secondary schools

1. Introduction

ICT is an abbreviation for Information and Communication Technology, it refers to the "combination of manufacturing and services industries that capture, transmit and display data and information electronically (OECD 2002:18; SAITIS 2000:3)". ICT can impact students' learning when the teachers are well developed in the context of integrating it into the curriculum.

"The development in ICT in Tanzania has a long history though as in many Sub-Saharan African countries, Tanzania faces challenges such as lack of good communication networks,

higher illiteracy, and inadequate government support as well as lack of power or energy sources (Thakrar et al., 2009; Tedre et al., 2010)". All these hinders the proper use of ICT in education sectors. The efforts towards the use of ICT in teaching and learning in secondary schools is increasing dramatically for specific reasons including increasing classroom interaction, for language and cognitive development (Collis & Moonen, 2001). In the African countries the studies in exploiting ICT are emerging very fast especially in teaching and learning processes in secondary schools, (Kigobe, 2013; Senzige & Serukesi, 2003).

In Tanzania the use of ICT can be traced back to years between 1960s and early 1970s as it started when primary and secondary schools were provided with radios to enable students to listen to educational programmes designed by the ministry of education in collaboration with Radio Tanzania. In 2003, the national Educational technology policy was formulated for the first time emphasizing on the use of a wide range of educational technology facilities; from radios and mobile phones to computers and Internet to meet educational objectives (Luhamya et al, 2012). But also the information and technology knowledge that implies the competence of a teacher about the use of ICT specifically when they are aware of computer based technologies and the pedagogical knowledge that stands for teachers' understanding of various teaching strategies related to classroom management, assessment skills, and classroom environment, could address effective teaching and learning and teachers competence in communicating the subject matter to students effectively which leads to high students' performance (Kohler et. al, 2014).

Despite of the fast emergence of ICT many countries are experiencing a drop down of students in engagement and participation in science and mathematics subjects ,these dropdowns are bringing debates on whether it is the teachers incompetence or is the lack of motivation in science and mathematics subjects to students is the problem, however effective learning of these subjects require the use of ICT which engage students in a flexible learning that allows dynamism in location, content and teaching approaches (Collis & Moonen, 2001).

This study proposed to investigate the teacher's competence in the use of ICT in science and mathematics subjects such as the use of computers, television, projectors, phones, and other software and hardware tools, as per the report by Tilya (2008) and Sugiyama (2005) reported that, majority of teachers in Tanzania are not using ICT in their teaching. But we are in the paradigm shift by focusing on using enhanced technology for teaching and learning mathematics and science subjects. The question comes: how are teachers capable of using ICT in teaching and learning the subjects? Therefore, this study focuses on the following objectives:

1. To determine ICT tools that teachers use during teaching mathematics and science subjects.
2. To determine the relationship between the ICT tools used in teaching and learning the subjects with students' performance.
3. To investigate the challenges that teachers face during the use of ICT when teaching the subjects and during the learning process.

We worked under the following hypotheses:
1. ICT tools that teachers use during teaching mathematics and science subjects are few.
2. There is a relationship between the students' performance in mathematics and science subjects with the ICT tools used in teaching and learning.
3. Teachers face challenges during the use of ICT when teaching and learning mathematics and science subjects.

2. Informative ICT in the literature

According to a research conducted by Jegede and his colleagues (2015) and Sa'ari, Wong, and Roslan (2005a) they found that teachers with high levels of competency in using ICT find information systems to be useful worldwide. The teachers approached the information system with greater confidence and displayed a lower level of anxiety and aversion to using it. Besides, the results showed that there was a weak positive correlation (r=.127, p < .05) between teachers' attitudes and their perceived competence toward ICT usage (Sa'ari, Wong, & Roslan, 2005b). The researchers argued that being competent in using ICT is an important asset. This showed that ICT competency of teachers played a significant part in establishing the concrete development of student's performance in different subjects. This positive relationship revealed that teachers with a high level of ICT competency will demonstrate a higher level of ICT application.

Another study conducted by Lau and Sim (2008) further clarified that teachers who are more competent in using ICT have reported more favorable perception toward the acceptance and ICT use in Malaysian secondary schools. Hence, the authors suggested that to develop their ICT competency, teachers' perception must change, and their ICT usage must increase. This result is consistent with the findings of the previous study that teachers who are competent in using ICT also have favorable attitudes toward ICT. Furthermore, the strong, positive relationship between ICT use and teacher's competence suggests that it would help to improve their student's performance in mathematics and science subjects.

The National Institute of Education, which is the sole teacher education institute in Singapore found that the teachers' ICT competencies and their student's performance were significantly related to their acceptance and use of ICT. These findings suggested that basic ICT competencies underpin teachers' ICT use in their instruction. However, based on the path analysis, pedagogy-oriented ICT competency does not yield any significant paths toward ICT use. The researcher found that this might be due to the target towards general pedagogy such as classroom management and the adaptation of existing electronic resources for teaching.

In Tanzania, findings indicate that at each school there is at least one teacher who is competent in using ICT devices. Using a repeated cross-sectional survey, data were collected from 297 teachers from different secondary schools in Tanzania who participated in ICT skills training in 2017, 2018 and 2019. Findings reveals that despite the existing challenges such as ICT infrastructure, high student-to-computer ratio, limited ICT knowledge and skills to teachers in learning and teaching, some schools have performed well with the process of using ICT in teaching and learning science and mathematics subjects at secondary level since the teachers who have acquired skills in using computer and Internet have utilized them particularly in lessons preparation. Furthermore, findings indicate that at each school there is at least one teacher who is competent in using ICT devices.

The Tanzania Institute of education developed an ICT curriculum to increase quality of teachers instructions and achievements through the use of cellphone and digital technology (Mwalongo, 2011), but also the Bright Education Trust Fund (BETF) was initiated to develop the capacity of teachers by training them how to use ICT to improve teaching and learning process. These efforts were to increase individual teacher's ability and capacity in using ICT in schools. Though teachers use computers to handle managerial and administrative functions, there is little adoption of ways to use ICT in classes for teaching and learning, therefore this study aims at investigating the competency of the teachers in using the ICT tools in teaching and learning science and mathematics subjects.

3. Methods

This study used the quantitative method whereby the descriptive design was used to investigate the teacher's competency on using ICT for teaching and learning mathematics and science subjects in public secondary schools because the design provides a summary of the nature of existing conditions in a certain issue.

3.1. Research Approach

The quantitative method was used in this study because this study focused on quantifying the collected data and numerical analysis of the data to describe the phenomenon under study. This method provides precisely explanations that can be measured systematically and communicated numerically (Creswell, 2008; Creswell, Fetters, & Ivankova, 2004).

3.2. Research design

The descriptive design was used in this study because the study focused on measuring once the phenomenon under study while establishing only associations between variables. The design sought to describe the current status of the identified problem or issue under study by providing systematic information of a phenomenon under study. In doing so, it requires a systematic selection of the units that needed to be studied and measurement of each variable (Creswell, 2008; Creswell, Fetters, & Ivankova, 2004).

3.3. Participants and Sampling Procedures

The study involved 70 mathematics and science teachers from secondary schools. Forty-eight were male teachers while twenty-two were female teachers. There were varied durations and years they have been working as teachers, that is there are 30 teachers who worked for less than 5 years giving a percentage of 42.9%, 24 who worked from 5-10 years which gives a percentage of 34.3% and there are 16 teachers worked for above ten years also giving a percentage of 22.9%, therefore this data gave clear information about the study. The large group are those who have worked for less than 5 years, this might be because many are recruited in the past 2 years.

The sampling procedures were conducted through random sampling where every teacher had a probability to be chosen in talking about their competencies in using ICT in teaching and learning process. This technique was used to collect data among the teachers as they had an equal probability of being chosen to give their views on the study.

3.4. Data Collection

Through the study, data were collected by using Questionnaires. A questionnaire is a research tool used to conduct surveys. It includes specific questions with the goal to understand a topic from the respondents' point of view. Questionnaires typically include closed-ended, open-ended, short-form, and long-form questions. Questionnaires can be a more feasible and efficient research method than in-depth interviews. They are a lot cheaper to conduct because in-depth interviews can require you to compensate the interviewees for their time and provide accommodations and travel reimbursement. The questions should be in written form as compared to interview questions.

3.5. Data Analysis

The quantitative data were summarized, coded and entered into the computer for processing whereby a statistical package for social science (SPSS) was used for analysis. Descriptive statistics such as frequencies and percentages were computed.

The study considered ethical issues toward collection of data by first seeking permission from the approved institutions for doing research, including TAMISEMI and heads of schools. The participants were asked to volunteer participating in the study and a consent form was given to the teachers to provide their consents before conducting the study.

4. Results and discussion

4.1. Teaching subjects that are enhanced by technology

The respondents address that all science subjects demand technology during the teaching and learning process. Table 1 gives the detailed information.

Table 1. Subjects enhanced with technology during teaching and learning process

Subject	Frequency	Percent	Valid Percent	Cumulative Percent
MATHEMATICS	14	20.0	20.0	20.0
BIOLOGY	25	35.7	35.7	55.7
CHEMISTRY	8	11.4	11.4	67.1
GEOGRAPHY	18	25.7	25.7	92.9
INFORMATION AND COMMUNICATION TECHNOLOGY	5	7.1	7.1	100.0
Total	70	100	100.0	

The findings from the Table 1 indicates that there are varieties of subjects that teachers use ICT tools whereby there are 14 teachers (20%) for mathematics, 25 (35.7) for biology, 8 (11.4%) for chemistry, 18 (25 7%) for geography, and 5 (7.1%) for information and communication technology. All teachers revealed that they use some ICT tools during their classes. As seen from the findings there are many Biology teachers compared to all others and the least are the ICT teachers, this means that there is a shortage of these teachers in schools which implies poor training of teachers in the ICT subjects.

4.2. ICT tools that teachers use during teaching mathematics and science subjects at schools

The respondents identified ICT tools that are used for teaching mathematics and science subjects in the classrooms, including desktop computers, laptops, tablets, and projectors. Table 2 gives the detailed information.

Table 2. ICT tools that are used for educational purposes at schools

In your school which ICT tools or devices are used for education purposes?				
Tools	Frequency	Percent	Valid Percent	Cumulative Percent
Desktop computer	7	10.0	10.0	10.0
Laptops and tablets	16	22.9	22.9	32.9
Projector	14	20.0	20.0	52.9
Printed media	18	25.7	25.7	78.6
others	15	21.4	21.4	100.0
Total	70	100.0	100.0	

Table 2 shows the summary of the ICT tools that are used for education purposes. From the findings shows that the large proportional of the respondents (teachers) are using the printed media, where by the results shows that, about 25.7% which is equal to 18 individuals and 21.4% which is equal to the 15 individuals use the printed media rather than using the desktop computer personal computer projector and other related tools in education purpose.

According to the findings, many teachers use printed media, this might be because they do not have the resources, the ICT tools at school leading to them using the mobile phones and printed media such as printed notes, photographs, diagrams, maps during teaching, but this can be reduced by training the teachers on how to use the available ICT tools in the school since nowadays many teachers own tablets and laptops so if they are trained, they can increase the use of these resources for teaching. According to Sameer et al.(2011), ICT enables self-paced learning through various tools such as assignments, computer uses as a result of this the teaching learning enterprise has become productive also it helps facilitate the transaction between teachers and students and enhancing teachers capacity and ability, this identifies the significance of using the ICT tools.

Teachers also identified the ICT tools that are often used for teaching mathematics and science subjects in a class, including phone and laptops. Table 3 gives the detailed information.

Table 3. ICT tools that teachers often use during teaching mathematics and science subjects

Tools	Frequency	Percent	Valid Percent	Cumulative Percent
Phone	24	34.3	34.3	34.3
Computer	8	11.4	11.4	45.7
Laptop	19	27.1	27.1	72.9
Projector	10	14.3	14.3	87.1
All of the above	9	12.9	12.9	100.0
Total	70	100.0	100.0	

Table 3 shows a summary of ICT tools which are often used for teaching in class. The finding shows that most teachers in school uses mobile phone for teaching where large number of respondents shows that (34.3%) which equal to 24 individuals used mobile phone for teaching followed by 19(27.1%) respondents which used laptop for teaching, 10(14.3%) used projectors, and 8(11.4) used computers for teaching but also there are those who used a mixture of all tools being 9(12.9%). These results can also be represented pictorially in Figure 1.
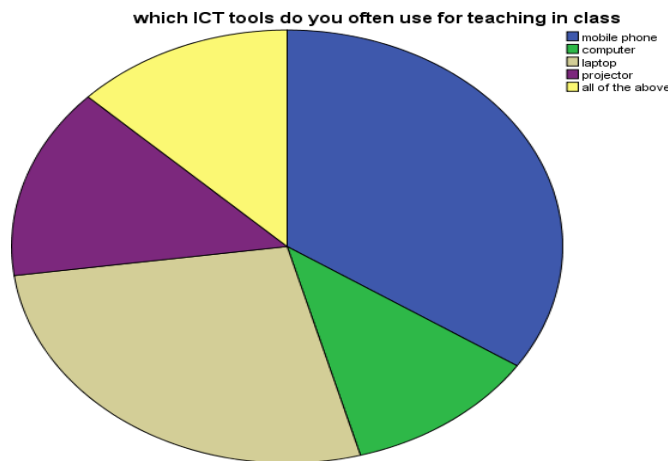
Figure 1. ICT tools often used for teaching mathematics and science subjects in a class

According to the findings many teachers use mobile phones and laptops rather than the other tools due to the fact that they are the ones that are easily available to them. Computers were least used because they are rarely found in schools, and there are limited experts in using them although the use of computers is crucial and useful over the smartphones. According to Kajal (2023) computers can be used for online education and research, with the help of the internet both teachers and students can find useful information about their projects, assignments, organize and store their teaching and learning materials respectively. Also, computers have a higher storage capacity than mobile phones. Therefore, schools should encourage the presence of the ICT tools since they enhance mathematics and science teaching at schools.

Teachers also presented the ways that ICT tools are used for teaching mathematics and science subjects in schools. Table 4 provides the detailed information.

Table 4. Ways in which ICT tools are used for teaching mathematics and science subjects in schools.

Ways ICT tools are used	Frequency	Percent	Valid Percent	Cumulative Percent
Creating materials for assignments	11	15.7	15.7	15.7
Making visual displays and videos to use in a class	10	14.3	14.3	30.0
Creating notes in word, power points or lessons	12	17.1	17.1	47.1
Presenting graphs, charts, images and photographs during teaching	17	24.3	24.3	71.4
Communicating with other teachers	9	12.9	12.9	84.3
None of the above	1	1.4	1.4	85.7
All of the above	10	14.3	14.3	100.0
Total	70	100.0	100.0	

The results in Table 4 and Figure 2 were generated to show how the respondents use ICT tools in teaching mathematics and science subjects. The study shows that at least each respondent (1 00.0%) has ideas on the uses of ICT tools for different purposes during teaching and other educational activities. The result shows that, the majority (24.3%) which equal to 17 individuals used ICT tools for respondents present graphs, charts, images and photographs during teaching, (17.1%) used ICT tools to create notes in word, power points or lessons, (15.7%) used ICT tools to create materials for assignments, (14.0%) make visual displays and videos to use in class and other used to communicates with teachers in school ,re being in response of 9 individual which equal to (12.9%) of respondents.
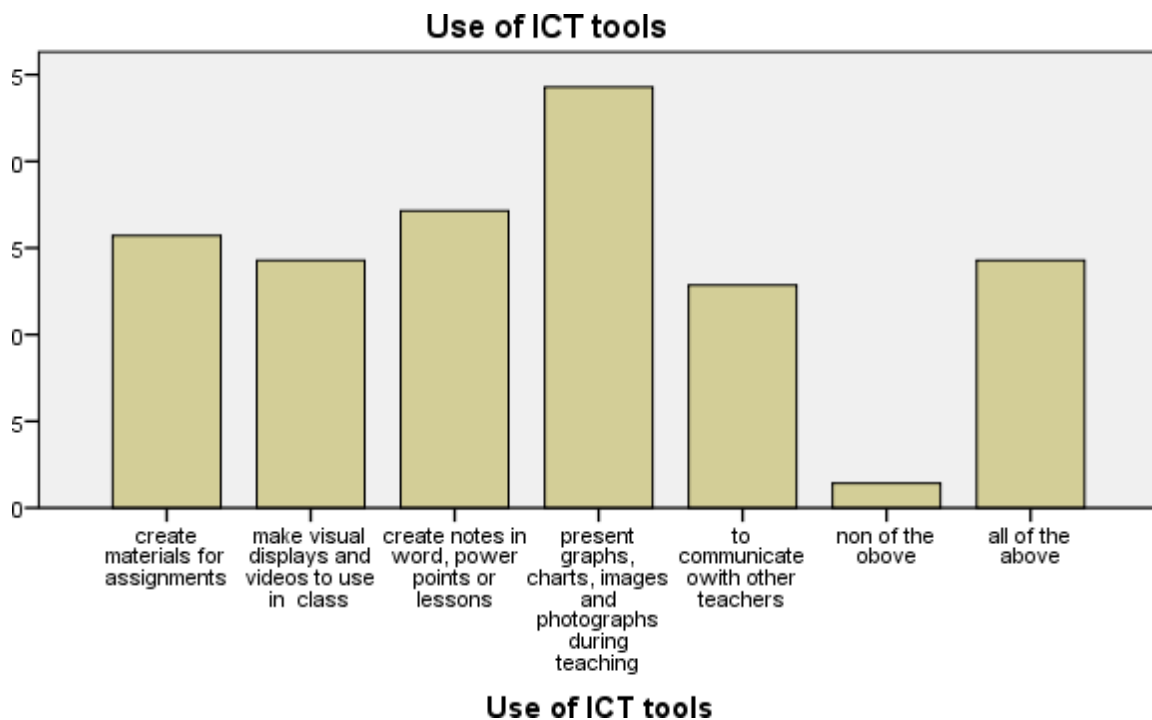

Figure 2. Ways that ICT tools are used for teaching mathematics and science subjects in schools

The findings showed that a large number of teachers use the ICT tools for presenting graphs, charts, images, and photographs during teaching although they also use for the other mentioned uses but the most chosen is that with 24.3%. The use of ICT tools for presenting images, photographs and charts is important for teaching and learning especially in science subjects. According to Triacca (2017), the use of images provides graphic representation to students that support brain work to find important things in their environments for easy learning. These tools were believed to provide learners with the visual based learning experience especially through pictures and graphs (Barab et al., 2015).

4.3. Relationship between the ICT tools used in teaching and learning and the Students' performance

The teachers present that the rate of learning and thinking among students increases while teaching mathematics and science subjects using ICT tools. Table 5 gives the detailed information.

Table 5. Teachers rating on students' learning and thinking ability after using the ICT tools in a class.

Students learning and thinking	Frequency	Percent	Valid Percent	Cumulative Percent
low	10	14.3	14.3	14.3
moderate	30	42.9	42.9	57.1
high	30	42.9	42.9	100.0
Total	**70**	**100.0**	**100.0**	

The findings above show the students' learning and thinking ability after using the ICT tools in their class. Majority of teachers said that using ICT tools in schools during teaching has a high contribution to students' learning and thinking ability. ICT tools help students digest learning materials which are acquired from their teachers. Also, ICT tools help students with critical thinking skills. This is in line with Pant and Muddgal (2018) in different levels, ICT can be used as a great tool by teachers to enhance order critical thinking skills in specific subjects. Also, using ICT tools, students enhance creative and critical thinking ability especially in problem solving settings (Wheeler et al., 2002). Furthermore, students' performance increases while using enhanced technology in teaching and learning mathematics and science subjects. Table 6 provides the detailed information from the respondents.

Table 6. Students' performance after the using ICT tools for teaching mathematics and science subjects in a class

Increase in performance	Frequency	Percent	Valid Percent	Cumulative Percent
yes	56	80.0	80.0	80.0
no	14	20.0	20.0	100.0
Total	**70**	**100.0**	**100.0**	

According to the information provided by the respondents, the majority of the teachers say that the use of ICT tools in the teaching and learning process of mathematics and science subjects increase the students' performance. Using ICT tools, students are able to see and understand well the learning materials projected on the computer screen in a class such as images, animation, notes and all other things which they cannot easily understand. Students learn easily which in turn increases their thinking capacity and learning achievements. The findings can also be represented using the pie chart (See Figure 3).
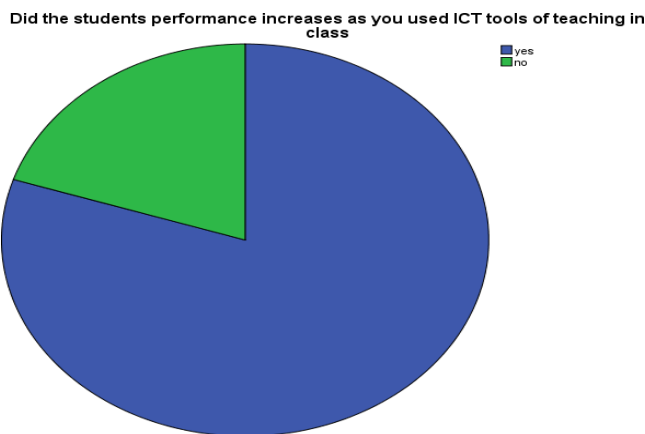
Figure 3. Students' performance increases while using ICT tools during teaching mathematics and science subjects in a class

By referring to the findings above many teachers have noticed the increase of students' performance after using the ICT tools. The correlation between ICT usage and academic performance is clear that it has great impacts on understanding, grades and class performance of learners (Badee & Abdul, 2023). Also, ICT tools boost academic performance in all subjects involved as it increases the level of motivation, interest, attitude and a sense of achievement (Ijaz et al, 2020).

4.4. The Challenges that teachers encounter while using ICT in teaching and learning process

Teachers provided some challenges they encountered for using ICT tools in teaching mathematics and science subjects, including poor infrastructure, lack of expertise, and funds. Table 7 provides the detailed information.

Table 7. The challenges that mathematics and science teachers face during using ICT tools in teaching and learning process

Challenges	Frequency	Percent	Valid Percent	Cumulative Percent
Poor infrastructure	37	52.9	52.9	52.9
Lack of expertise	20	28.6	28.6	81.4
Capital problem	13	18.6	18.6	100.0
Total	**70**	**100.0**	**100.0**	

During the teaching and learning process, the majority of the teachers experience poor infrastructures as the major problem such as shortage of rooms for conducting sessions, large numbers of students in the class that makes it difficult for teachers to conduct the session well, and unreliable electricity supplies at schools. Furthermore, teachers have experienced the problem of lack of expertise who are responsible to train the students and also the issues of funds have been depicted as the big challenge for the schools and teachers to buy the ICT tools, offer services and pay some experts who help the students on the ICT learning programs. Figure 4 expresses the results pictorially.
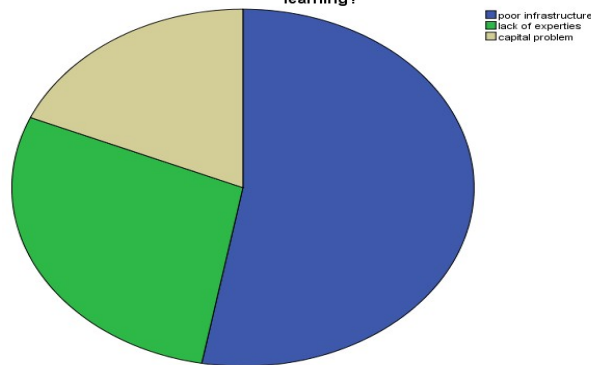
Figure 4. The challenges that teachers encounter while using ICT in teaching mathematics and
science subjects

The results show that a critical issue encountered by the teachers is poor infrastructure, this
is to say there are insufficient resources in schools, the ICT tools are limited in schools that
the teachers find it difficult to utilize the lessons. Poor infrastructures hinder the proper use
of these tools unless schools get access to ICT facilities and infrastructure. This in turn
improves the quality of education and productivity (Bariu, 2020). Also, lack of expertise, that
is the teachers lack knowledge and skills in teaching using the ICT tools and they might be
not eager about the changes and integration of learning associated with bringing the ICT tools
into their teaching practices (Habibu, Mamun & Clement, 2012).

Teachers also provide suggestions to overcome challenges for using ICT tools in teaching
and learning mathematics and science subjects.

Table 8. Ways to overcome challenges that teachers encounter while using ICT tools in
teaching and learning mathematics and science subjects

Ways to overcome challenges	Frequency	Percent	Valid Percent	Cumulative Percent
Improving electricity power	10	14.3	14.3	14.3
Developing consistency	13	18.6	18.6	32.9
Increasing ICT tools	26	37.1	30.0	62.9
Using the printed media such as photos and map	21	30.0	37.1	100.0
Total	**70**	**100.0**	**100.0**	

From Table 8 and Figure 5, the teachers' response is to increase ICT tools, which is seen as
the big way to overcome the challenges; however, some said the use of printed media such as
photos and maps, printed notes and diagrams will improves their studies, also improving
electricity power and developing the consistency of teachers have been taken as the good ways
to solve the problems. This means that, when these challenges are taken into consideration, it
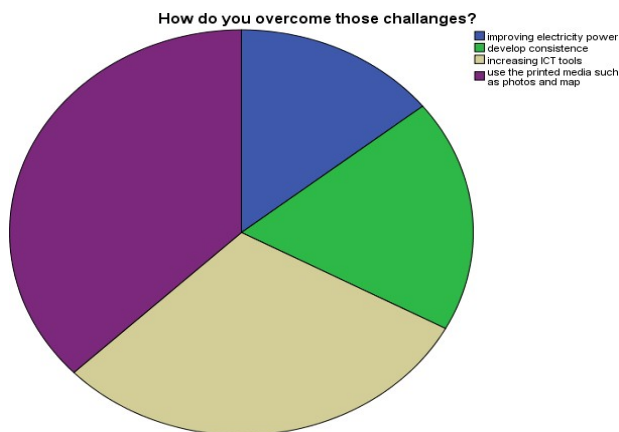will increase student's performance on the learning processes.

Figure 5. Ways to overcome challenges that teachers encounter while using ICT tools in teaching and learning mathematics and science subjects

According to the findings, highly suggested ways to overcome the challenges are by using alternative techniques and increasing ICT tools at schools. There are insufficient ICT tools in schools so the teachers have limited options, although together with the use of these printed media the increase of availability of ICT tools in schools is as far as helpful, since According to Sameer and colleagues (2011), ICT enables self-paced learning through various tools such as assignments and computer uses. This identifies the significance of using the ICT tools during teaching mathematics and science subjects.

5. Conclusion

The research findings have been considered as per the response from teachers and it shows that teachers are already witnessing some of the significant consequences of ICT and its impact on education. A new era of education has been started which necessarily demands a new role of teachers, students and the education system. In the era of ICT, it will be difficult to improve it if efforts are not made to promote ICT education. One of the strategies to be adopted in this regard is the production of teachers who have developed competencies for the successful instructional use of ICT in education. Those teachers are called 21st century teachers who will possess the technological, pedagogical, and social competencies in them and they will shape the personality of their students.

To ensure the development of teachers' ICT competencies, three things should be taken into consideration. First, ICT should be a compulsory course in all teacher preparation institutions. Teacher preparation should not be based on training for "Computer Literacy" but should prepare teachers for using technologies to construct, represent and share knowledge in real life authentic contexts, an innovative model of pre-service teacher education should be developed that fulfill our present requirement, also both theory and practice related to the technological and pedagogical competencies should be the compulsory course of the teacher preparation programs. Second, sufficient facilities and resources should be provided to teachers to practice the ICTs in the teaching-learning process. They should be given an environment in which they develop their ICT-based competencies, also computers and the internet should be provided in the schools so as to provide access to ICT to both teachers and learners. Third, professional development programs (PDP) should be organized for the teachers in which emphasis should be laid down on the development of ICT-pedagogical competencies.

6. Conflict of Interest

The authors declare that there is no conflict of interest.

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