The effective use of ICT for improving the teaching of Biology subject in selected secondary schools of Rulindo District, Rwanda

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Abstract

Information and Communication Technology (ICT) was found to be important in improving teaching and learning. However, the use of this contemporary paradigm was found to be not effective due to different factors. Within this perceptive, this study aimed to investigate the degree at which ICT was used in teaching Biology and the influence of trainings and availability of ICT tools on its successful use in selected secondary schools of Rulindo district. Descriptive survey research design was used to collect data through interviews and questionnaires. From a population of 132 participants, a sample of 98 participants including Biology teachers, Head teachers, and District representative were participated in this research. The obtained data were analysed both qualitatively and quantitatively. The results showed that ICT was not effectively used in teaching Biology. This was associated with the shortage of adequate trainings and ICT related infrastructure. Therefore, more investment in providing ICT related infrastructure and adequate teachers' training is needed for successful integration of ICT in teaching Biology.

Key words: Information and Communication Technology, ICT infrastructure, Teaching and Learning, Biology, ICT trainings.

Introduction

In the current education system, teachers are encouraged to use innovative strategies allowing learners in acquiring competencies required for the 21st century to adapt in this changing world. The use of Information and Communication Technology *(*ICT) in teaching and learning process is one of the innovative strategies which is being adopted in different countries around the world (Bhasin, 2012). Based on the 2030 United Nations (UN) Agenda for sustainable development, each United Nation member country has to use ICT in different domains for promoting national development (UN, 2016). This has been also stipulated under the 17th goal of UN international framework where ICT has been recognised to be an important tool for national development. In line with this UN agenda, African Union summit of 2015, emphasized on ICT infrastructure development as top priority for achieving the vision 2063. The policy could be achieved only if all African countries provide a reliable and affordable ICT related services such as increasing broadband connectivity, accessibility of ICT at all school levels, and investing in ICT related project (African Union Commission, 2015).

The integration of ICT in teaching and learning process was found to help in creating a conductive learning environment in which students participate actively and constructively (Volman & Van, 2001). It is therefore used in developing the abilities of students in terms of communication, problem solving, cooperation and lifelong learning (Plomp, Brummelhis & Rapmund, 1996). The innovative use of ICT in teaching and learning, enhances learner-centered method which is an important approach for effective teaching and learning process (Drent & Meelissen,2008). Therefore, the adoption of this technology is necessary for enhancing the students learning in every subject (Mwanda; Mwanda; Midigo

& Maundu, 2017). This will engage students in developing decision making, critical thinking and problem solving behaviors (Grabe & Grabe, 2001). In teaching biology, ICT (especially when using visuals and animations) makes the learning environment more enjoyable, motivating and attractive by increasing learners' attention to the subject content thus promoting the effective teaching and learning process (Tomljenović & Zovko, 2016).

Generally, ICT is used in different activities across different subjects. The common generic ICT applications include; word processing for text development, power point for content presentation, excel for calculations and internet for exploring different web sites in terms of getting the required content from different sources (Enu; Nkum; Ninsin; Adoma & Korsah, 2018). These generic ICT skills help students to acquire relevant competences in terms of doing and presenting their home works and sharing content with other communities. On the other side, specific ICT tools and applications (software) were developed for teaching and learning Biology as well as other science subjects. Among these software we may include the SimBio software for DNA replication (The SimBio Consortium, 2001), the NeuroBytes for improving the teaching and learning of nerve transmission across the synapses (Isabel, Vignesh & Rogers 2018) that was difficult to be grasped through the traditional didactic methods (Šorgo, Verčkovnik, & Kocijančič, 2010). On the other side, the virtual laboratories were also found to play a great role in teaching and learning Biology. Through this scenario, students are guided to understand the analogies of natural phenomena through visual representation and realistic simulations based on real phenomena (Sommer & Sommer, 2003). The virtual labs use the power of computerized models and simulations and a variety of other instructional technologies to replace face-to-face lab activities (Scheckler, 2003). This kind of learning process enhance students to get access to the hands on activities that are not available in their physical laboratories (Muhamad, Zaman, & Ahmad, 2012).

Within virtual laboratories, we may found the virtual frog dissection also useful in improving Biology teaching. Interactive frog dissection provides both realistic imagery and opportunities for student practice on frog dissection and anatomical identification (Kinzie, Burch, & Boker, 1996). Together with the above, different applets (small programs) have been developed for educational purpose. These include; simulations of experiments and animated images (Demkanin, Kibble, Lavonen, Guitart, & Turli, 2008). Data logging has been also developed for helping teachers in science practical experiments. The teaching Biology concerns with the living organisms and life processes, however, some organisms are found in remote areas difficult to be accessible by every student. With the use of digital camera, the images of different living organisms can be brought in classroom (York Universty, 2002).

Integrating ICT in teaching and learning biology, provides teachers with opportunities to bring nature into classroom activities (Demkanin et al., 2008). The Edmodo platform, which is an e-learning model has been found to be successful in teaching Biology (Végh & Elbert, 2017). It has been recognized that ICT increases students' motivation through facilitating the exchange of information between groups of students (Senthilkumar, Sivapragasam, & Senthamaraikannan, 2014). Kareem (2018), described how multimedia strategies are the best methods to be adopted for

making teaching Biology meaningful. However, different factors were found to influence the successful use of ICT in teaching and learning process. Some of these factors include: teachers' skills and competence, teachers' perception, teachers' trainings and availability of ICT related infrastructures (Ndayambaje & Ngendahayo, 2014).

In terms of effectively use of ICT in teaching and learning Biology, adequate trainings on using different ICT tools and software in teaching Biology are needed. The effective trainings should focus on providing teachers with a structured formation in technology-based activities and environments so that they can leave traditional methods of teaching to explore and design modern learning environments (Yamith, 2012). It is assumed that adequate trainings and facilities increase ownership in teachers for using ICT in classroom activities (Abuhmaid, 2011). The teachers with inadequate trainings on using ICT tools have been accused of showing low confidence and competence in using ICT in education. Additionally, the lack of ICT related trainings and technical support may affect teachers' willingness in the adoption and use of ICT in education (Goktas, Yildirim & Yildirim, 2008). The successful use of ICT depends on the degree at which teachers are trained and supported (UNESCO, 2003).

On the other hand, the ICT related infrastructures plays a great role in successful use of ICT in teaching and learning. In this regards, most of African countries are increasing computers and other ICT facilities in different schools but the gap in ICT infrastructure still to be a big challenge (Hennessy, Harrison & Wamakote,2010). The shortage of ICT infrastructure such as: computers, scanners, mobiles phones, printers, projectors, radio, camera recorders, TV sets and software such as: data logging, simulations, virtual experiments tools, electricity and internet connection was found to be a serious obstacle in using ICT for teaching and learning process (Šorgo et al., 2010). Mumtaz (2006) stated that, the shortage of hardware and software is one of the reasons that prevent the effective use of ICT in classrooms. Mulwa & Kyalo (2011), Njoroge; Margaret & Joab, (2017) stated that, the decisions of teachers on using computers in classrooms tend to be influenced by the accessibility and availability of relevant infrastructures. Connectivity to electricity and internet facilities are also highly needed during integration of ICT in teaching and learning process. Nevertheless, electricity and internet connectivity are still a big challenge in many developing countries mostly in Africa (Mathevula & Uwizeyimana, 2014). This was also confirmed by the findings from the of Eze & Adu (2015) that revealed that the lack of internet connectivity and electricity was a barrier to the effective use of ICT in many African schools.

In terms of promoting the use of ICT for improving teaching and learning process, different nations are competing with investing in all requirements for the implementation of this contemporary policy. In this context, the Rwandan government was not left behind. Since 2016, the ICT in education policy was initiated for ensuring equitable access to the quality education that could help in transformation of Rwandan citizens into skilled human capital for social-economic development. This could be achieved through use of ICT in providing the diversity of learning methods and materials as well as enhancing communication and collaboration skills among students (MINEDUC, 2016). It is in line with the UNESCO recommendation stating that the ICT could be used in improving the quality of education by equipping

students with abilities needed to succeed and thrive in today's complex, technology-based global economy and to be the active 21st century global citizens (UNESCO, 2011).

Regardless to the great efforts invested in the use of ICT in teaching and learning process, the study of Wallet & Kimenyi, (2015) has found some distributed computers in Rwandan schools stored and unused due to lack of electricity. The 2016 MINEDUC report, showed that only 32% primary schools and 51% secondary schools were connected to electrical grid while only 13% secondary schools have internet facilities. The report further revealed that, only 17791 Rwandan teachers were trained in basic ICT skills while 5584 trained in ICT-enhanced pedagogy. This represented 26% and 8% of all primary and secondary schools' teachers respectively (MINEDUC, 2016). However, non-available reports on the teachers' trainings towards the use of specific ICT software in teaching Biology and other science subjects, therefore the practical use of ICT in teaching and learning process is questionable.

Based on the importance of using ICT in teaching and learning process it was imperative to conduct this research on assessing how ICT is effectively used for improving teaching Biology subject in selected public secondary schools of Rulindo District in Rwanda. Specifically, this research aimed at investigating the common areas under which ICT was being used in teaching and learning process and effect of trainings and ICT infrastructure on the level of using ICT in teaching Biology. In terms of achieving the stated objectives, two research questions were set. These questions include: To what extent are Biology teachers using ICT in teaching Biology? What is the influence of ICT trainings and availability of adequate ICT infrastructure on the effective use ICT in teaching and learning Biology?

Research methodology

This section discusses the research design, data collection instruments, validation of research instruments and the methods of presenting and analysing the findings.

Research Design

A descriptive survey research design was used during this study. Within this context, both qualitative and quantitative data were collected in mixed method (Creswell, 2013). This approach has been adopted due to the fact that a single method was not appropriate to obtain all required data for the phenomena under exploration.

Target population, sampling procedure and Sample size

The targeted population was 132 participants including 80 secondary school Biology teachers, 49 head teachers 3 staff in charge of Education at district level. From this population, a sample of 98 participants was selected to participate in the study. These participants included 64 Biology teachers randomly selected from public and government aided secondary schools; 33 head teachers purposefully selected from some of the school corresponding to the selected Biology teachers depending on their availability and 1 staff from the Education unit at district level was also purposely selected based on the

fact that their functions are related to secondary schools' education. The calculation of the sample of participants to participate in the research was based on the following Yamane's formula. $n = \frac{N}{N(e^2)}$, in this formula; n= sample size, N=population size, e=estimated error (5%) (Yamane, 1967). By using this formula, the sample size was calculated as follow: $n = \frac{132}{1+132(0.05^2)} = 98\ participants$

The school head teachers and staff from education unit at District were involved in this research for obtaining the information related to support provided to all teachers and Biology teachers specifically in terms of integrating ICT in teaching and learning Biology as well as the future plans for effective use of this contemporary policy.

Ethical consideration

Before collecting data, the researcher obtained a permission letters from University of Rwanda-College of Education, Gasabo District and Rulindo district. Additionally, the research participants were given the consent forms to sign for participation agreement and re-assured that they can withdraw from the research anytime they want without any consequence.

Data collection tools

Data collection tools included 5 points Likert scale questionnaires and rating scale questionnaires administered to Biology teachers and semi-structured interviews for head teachers and District staff. The Likert scales comprised of the following responses: 1 = strongly disagree, 2= disagree, 3=neutral, 4= agree and 5= strongly agree. All questions to be answered were elaborated based on the research objectives.

Validity and Reliability of data collection tools

For ensuring validity and reliability, data collection tools were piloted in 4 secondary schools of Gasabo District in Kigali City after which Pearson coefficient correlation (r) and Cronbach alpha (α) were computed by using SPSS software (16.0 version). The questions with Pearson correlation coefficient <0.5 were eliminated while others were adjusted. In addition, data collection tools were exposed to the research experts from The University of Rwanda for detecting the clarity and relevance of research questions, then advanced adjustment was undertaken based on their comments. After addressing all comments from experts for the validity and reliability of the data collection tools, the reliability coefficient (Cronbach alpha) was computed and found to be 81% indicating the suitability of questionnaire to collect the required data.

Data analysis process

After entering and coding quantitative data in SPSS software version 16.0, descriptive statistics was used in calculation of mean, percentages, and standards deviation and the findings were presented in different tables and graphs. For assessing the influence of trainings and ICT infrastructure on the level of using ICT teaching and learning Biology, a Chi

square (X^2) and correlation analysis were respectively used. Additionally, the data obtained from interview were qualitatively analyzed and presented in the form of sentences to support quantitative findings.

Results Presentation and Discussion

The findings obtained from the research questionnaire provided to Biology teachers were presented in the form of graphs and tables. These findings were complemented by those from the interviews with Head teachers and District education unit representative.

Demographic information of Biology teachers involved in this research

This section presents the information related to the individual attributes of teachers who participated in this research. The characteristics investigated were the gender of participants, teaching experience, level of education and trainings.

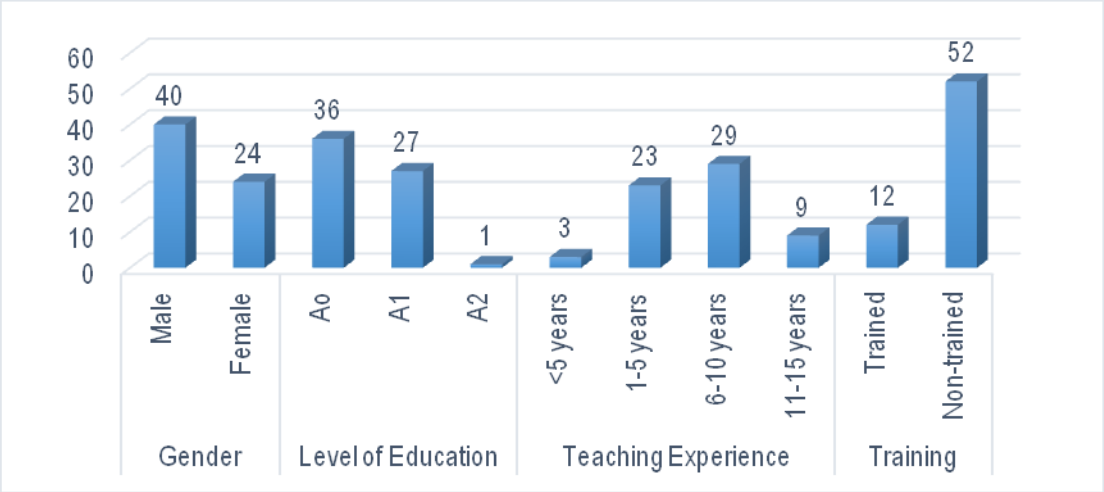

Fig1. Gender, level of education, teaching experience and trainings received by Biology teachers (n=64)

The findings in the figure 1 above showed that 40 Biology teachers among 64 participated in this research were males while the females were 24. Among these participants, 36 had bachelor's degree of education (A0), 27 advanced diploma (A1) and only 1 Biology teacher has diploma (A2). Concerning the teaching experience of Biology teachers involved in this research, 3 had less than 5 years, 23 between 1 and 5, 29 Biology teachers had 6 to10 years of experience while those with 11 to 15 years of experience were 9. Based on the findings from this figure, the majority of respondents (52) were not trained on using ICT for teaching purpose while only 12 were trained.

This small number (12) of trained Biology teachers towards the use of ICT in teaching and learning Biology, may prevent the effective use of ICT in teaching and learning process. Professional development (training) is one of the methods that could be used for equipping teachers with relevant skills needed in terms of implementing ICT in teaching and learning process. Professional development increases teachers' skills, teachers' morale and motivation (Baylor &

Ritchie, 2002). Based on the impact of teachers' trainings on the use of ICT in teaching and learning process, its provision was found to be an important issue (Ndayambaje & Ngendahayo, 2014).

The use of ICT for teaching and learning Biology

ICT can be used in different aspects during teaching and learning Biology. This use may start from the generic use of ICT like storing and presenting Biology contents to the specific complex biological phenomena like virtual laboratories for different experiments. However, the level of using ICT in teaching and learning process may vary depending on the expertise of the teachers. In this regards, the table below summarizes the findings on the average use of ICT in various aspects of teaching and learning Biology for Biology teachers involved in this research.

Table 1: The level at which ICT is used in different aspects related to the teaching and learning Biology

Variable	n	Mean	Std-dev	Remarks
The use ICT in preparation of Biology lesson	64	1.7	.95	Sometimes
The use ICT in explaining Biological phenomena	64	1.4	.60	Never
The use ICT in preparation of scheme of work	64	2.7	.89	Frequently
The use ICT in marks recording and analysis	64	1.6	.50	Sometimes
The use ICT in carrying out virtual experiments	64	1.1	.78	Never
The use ICT in collecting images and videos of organisms and their interactions to be presented in classrooms	64	1.2	1.00	Never

n= number of respondents, **std-dev=** standard deviation

In the table 1 above, the research participants used three-points rating scale (1=Never, 2=sometimes and 3=Frequently) for choosing in 6 statements related to the use of ICT in different activities related to the teaching and learning Biology. After recording the ratings provident by Biology teachers who were involved in this research, the average of ratings was calculated against each question. In these averages of rating, the mean value less than 1.5 express the non-use of ICT (Never), the mean value ranging from 1.5 to 2.5 indicated a moderate use of ICT (sometimes), while the mean value from 2.5 to 3 expressed the excellent use of ICT (frequently).

Based on the findings presented in table 1 above, most of Biology teachers involved in this research used ICT in generic aspect (see statements rated sometimes and frequently). However, it has been found that ICT was never used in specific activities related to the teaching and learning Biology like virtual experiment, explaining different biological phenomena and collection of digital images to be presented in Biology classroom. This shows that, the use of ICT in teaching and learning of Biology in the selected secondary schools of Rulindo district is at low level as Biology teachers still relying on only generic applications on ICT rather than adopting the specific software and applications used in teaching and learning Biology. This concurs with the finding of Ghavifekr, Kunjappan, Ramasamy , Anthony & My, (2006) who

found that teachers usually use ICT to present or demonstrate examples to students as well as accessing students' results and keep track of their progress. The generic use of ICT in teaching and learning process among teachers in schools selected was also confirmed by school Head teachers during interview as most of them said that majority of teachers (including Biology ones) in their schools used ICT in preparation of scheme of work and lesson plan due to the limited ICT resources including the adequate software for teaching specific subjects. However, some of the Head teachers pointed the lack of adequate trainings as the barrier for the effective use of ICT in teaching and learning process.

One of the interviewed Head teachers said: *"in our school we only have 50 computers used by ICT teachers while teaching ICT subject, so we cannot have computers to be used by every teacher including Biology teachers". Additionally, we do not have such software for teaching specific subjects.* This statement is in contrast with the findings of Mwanda; Mwanda; Midigo & Maundu, (2017) who advocate cross-curricular use of ICT as the effective method of integration of ICT in education than being taught as a distinct subject. According to Mulwa & Kyalo (2011) ICT equipment are very crucial for teachers' readiness to adopt e-learning in curriculum delivery. Similarly, Njoroge; Margaret & Joab, (2017) stated that, the decisions of teachers on using computers in classrooms tend to be influenced by the accessibility and availability of relevant infrastructures. The issue of insufficient ICT infrastructure was also supported by one staff from education unit at District by confirming some barriers faced by teachers during integration of ICT in educational process like low network capacity across the district, insufficient ICT tools, lack of adequate digital content (videos and simulations) and software specialized to different subjects including Biology. These findings are in line with those of Mumtaz (2006) stating that, the shortage of hardware and software is one of the reasons that prevent the effective use of ICT in classrooms. However, a staff from the District Education unit said that they were more different projects for distributing more ICT tools across different schools of District.

Within the same perspective, the inadequate use of ICT in teaching and learning Biology could also be associated with the shortage of adequate ICT training identifies in Biology teachers participated in this research (see figure1.). The lack of adequate trainings on the appropriate use of specific software in teaching and learning Biology could prevent teachers to adequately use ICT. The study of Beggs (2000) found that one of the top barriers to teachers' use of ICT in teaching was the lack of training.

The effect of training on the level of using ICT in teaching and learning Biology

The level of using ICT in teaching and learning process could be associated with the competences of teachers. One of the important methods of acquiring these competences is through trainings. I this regards, the influence of trainings on the level of using ICT in teaching and learning Biology was invested and the findings are presented in the table 2 below.

Table 2: The influence of ICT training on its use in teaching Biology

Statement	X^2	p	Difference	
1: Use of ICT to prepare biology lesson	9.48	0.009	p< 0.050	Significant
2: Use of ICT students' marks records and analysis	5.80	0.016	p< 0.050	Significant
3: Use of ICT for making scheme of work	1.52	0.216	p>0.050	Non-significant
4: Use of ICT explain different biological experiments	10.50	0.005	p<0.050	Significant
5. Use of ICT in recording the digital images of organisms	9.50	0.013	p<0.050	Significant
6. Use of specified ICT software in biological experiments	7.89	0.002	p<0.050	Significant

X^2: Chi-square, **p**=significant level

The table 2 above summarized the findings of X^2 used to assess the use ICT among trained and non-trained Biology teachers. From these findings, it is observed that the p-value is less than 0.050 for the 5 statements (questions) and greater than 0.050 for only one statement. This showed a significant difference on using ICT between trained and non-trained Biology teachers. It can therefore be inferred that trained Biology teachers use ICT more than non-trained Biology teachers. According to Yamith (2012), ICT training should aim at providing teachers with a structured formation in technology-based teaching to explore and design modern learning environments. However, a few numbers of teachers were trained on using ICT in teaching and learning process (see the figure 1). In the same line, the findings of Pelgrum and Law, (2003) revealed that there were not enough training opportunities for teachers in using ICTs in a classroom environment. During the interview with Head teachers on occurrence of ICT related continuous professional development (CPD) among their staff, they declared that a few of trainings were conducted but they were only related to basic use of ICT tools like in using word, excel and power point programs. No training on using ICT in specific subjects was organized as they declared.

The Impact of infrastructure on using ICT in teaching and learning Biology

The effective use of ICT in teaching and learning is highly depending on the adequate ICT related infrastructure available for teachers and students. The table 3 below presents a summary on Biology teachers' agreements on availability status of some ICT related infrastructure for teaching and learning Biology within the selected schools.

Table 3: Availability of ICT infrastructure on teaching and learning Biology

No	Item	n	Mean	Std. Dev	Remarks
1	Accessibility of computer	64	2.3	1.233	Available but not adequate
2	Internet connectivity	64	2.2	1.291	Available but not adequate

3	ICT Tools (Projector, printer, scanners)	64	1.8	1.283	Available but not adequate
4	Digital content (Simulations, videos)	64	1.6	1.202	Available but not adequate
7	Virtual laboratories software	64	1.0	1.00	Not available
8	Imaging system	64	1.2	.98	Not available
9	Video cameras	64	1.4	.80	Not available

n= number of biology teachers involved in this research**, Std. dev:** standard deviation

In the table 3 above, the research participants were requested to choose among three points of rating scale (1= not available, 2=available but not adequate and 3=available and adequate) in relation to the ICT infrastructure. The mean ranging from 1 to 1.5 indicated non-availability of ICT infrastructure, between 1.5 to 2.5 available but not adequate while the mean above 2.5 expressed available and adequate. From the findings in that table, it has been found that the few available ICT infrastructures were not adequate while others were not available. This could affect the level of using ICT in teaching and learning Biology. As the virtual laboratories and other specific software for teaching and learning Biology were not available, it could be difficult to effectively use ICT in teaching and learning Biology. It is in line with the findings of Šorgo et al., (2010) stating the shortage of ICT infrastructure such as: computers, scanners, mobiles phones, printers, projectors, radio, camera recorders, TV sets and software such as: data logging, simulations, virtual experiments, electricity and internet connection were serious obstacle in using ICT for teaching and learning process. Similarly, Ginsberg and McCormack 1998 cited by Gilakjani, Sabouri & Zabihniaemran, (2015) stated that teachers' issues and potential barriers to the implementation of computers are software resources related.

Similarly, the lack of adequate simulations and videos was also identified to be missing in selected schools which could be a barrier against the use of ICT in teaching and learning Biology. This contrast the findings of McFarlane & Sakellariou (2002) suggesting that computer-simulation may provide simultaneous representation of real and theoretical behaviour of a system under investigation for comparison. In the same context, most of the interviewed head teachers agreed with shortage of ICT resources in their schools. This issue was also confirmed by a staff from education unit at District by assurance in terms ICT tools provision through SMART classroom establishment was given.

Table 4: Relationship between availability of ICT infrastructure and the level of using ICT in teaching and learning Biology

		Availability of ICT infrastructure
Level of using ICT in teaching and learning Biology	Pearson correlation	.734**
	Sign. (2-tailed)	.000
	n	64

** Correlation is significant at 0.01 level (2 tailed)

A table 4 above summarized the findings on the Pearson's correlation coefficient calculated to evaluate the relationship between availability of ICT infrastructure and the level of using ICT in teaching and learning Biology. From this table, a significant relationship is shown between availability of ICT infrastructure and the level of using ICT in teaching and learning Biology as the obtained Pearson's correlation coefficient (r=.734) is greater than p-value of .000. The above findings are similar with the findings of Ghavifekr et al.,(2006) stating that the use of ICT is influenced by teachers' extrinsic factors including the lack of resources, time, access and technical support. On the other hand, Mwendwa (2017) has found that the availability of adequate ICT resources determines its effective integration in teaching and learning process. Technologies such as interactive whiteboards, e-conferences, educative software and education portals among others, have been proved as an essential boost to classroom activity, learning motivation and general inquisitiveness (Gulbahar, 2007).

Conclusion and recommendations

This study investigated the effective use of ICT for improving the teaching and learning Biology. Within this perspective the level at which ICT was used in teaching Biology and the effect of trainings and ICT relate infrastructures were assessed. Based on the findings from the research, it was noted that most of Biology teachers involved in this research were not effectively used ICT in teaching and learning Biology. This is because ICT was generally found to be used in only general application like Biology notes preparation and presentation as well as scheme of work preparation but few of them used some specific applications like simulations and virtual experiments in teaching and learning Biology. The inadequate use of ICT was identified to be associated with the lack of adequate trainings and insufficient of adequate ICT infrastructure.

ICT integration was described as important paradigm in teaching and learning; therefore, all educational agents have to invest in providing the adequate trainings related to the use of ICT in teaching different science subjects. These trainings should be tailored in line with the needs of teachers who are requested to use the specific ICT tools and software in teaching and learning process. Additionally, more investment is needed in terms of equipping schools with adequate ICT infrastructure as it has been found that they play a great role in this aspect.

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