

Information, Communication and Technology (ICT) Integration in Biology Teaching and Achievement of Learning Outcomes in Nairobi City County, Kenya

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ABSTRACT

Biology is vital for a country's advancement in health and the environment. Researchers have reported that integration of Information and Communication Technology (ICT) in Biology teaching is more likely to improve the achievement of learning outcomes. Even though educators are aware of the positive impact, it has been reported that ICT integration in Biology teaching is minimal. Kenya has consistently posted a dismal achievement of learning outcomes in Biology as per the Kenya National Examinations reports 2013-2023. This study thus examined the influence of ICT integration in Biology teaching and students' academic achievement. The study used a mixed-methods approach. Within mixed approach, the study used an explanatory sequential design. The researcher first conducted a quantitative phase using questionnaires. The quantitative data was analyzed and the results used for in-depth study in selected schools and key informants in the qualitative phase. FGDs, In-depth interviews and class observations were used to collect data in the qualitative phase. The study was conducted in Nairobi City County, encompassing 114 public secondary schools. Participants comprised Biology teachers, students and subject matter experts from the Kenya Institute of Curriculum Development (KICD), the Centre for Mathematics, Science and Technology Education in Africa (CEMASTE), and Biology education lecturers from Kenyatta University. The findings revealed that ICT integration was rare even though this may help learners achieve cognitive learning outcomes such as remembering, understanding and analysis; affective outcomes such as developing a positive attitude towards Biology; ICT integration for simulations and animations enable achievement of learning outcomes up to the analysis level and enhance students' positive attitudes. It was therefore concluded that Biology teaching in practice with dismal ICT integration facilitated the development of lower-order learning outcomes.

KEYWORDS: Biology Teaching, ICT Integration, student achievement, Nairobi City County

1. INTRODUCTION

Globally, many countries have invested massive resources in the teaching and learning of Biology and other sciences, as illustrated by nations such as Australia, Malaysia, Ireland, Chile, South Korea, China and Finland (Boudry & Pigliucci, 2018). African countries have also made efforts in promoting Biology and science education. In Nigeria, for example, the Federal Ministry of Science and Technology of Nigeria has popularized Biology education and other science subjects for the country's economic development (FME, 2018). This is the scenario as it has been realized that for a country's better health development the knowledge of biology is vital and hence the importance of biology teaching and learning.

In Kenya, the Vision 2030 Program identifies Biology as a science which is a pillar for social and economic development. The Sessional Paper No.1 of 2005 further amplifies the role of teaching in the promotion of science education, of which Biology is included. There are two other Sessional Papers, namely No. 14 of 2012 and No. 2 of 2015, supporting the idea of high-quality education for sciences. The development of the health sector in Kenya, just like in other countries, depends on quality Biology teaching. The Kenya National Examination Council reports of 2013-2020 have, however, shown poor achievement of learning outcomes in Biology. This being the scenario, there is a need to examine the teaching of Biology so as to rectify the dismal achievement of learning outcomes in Biology (KNEC, 2022).

Evidence from research has shown that education systems are not up to the challenge in science teaching, leading to a decline in achievement of learning outcomes in science disciplines (Fernandes, Rodrigues, & Ferreira, 2019). In Kenya Sessional Papers, namely No. 14 of 2012 and No. 2 of 2015, amplify high-quality education for sciences. The development of the health sector in Kenya, just like in other countries, depends on quality Biology teaching but the National Examination Council reports of 2013-2020 have, however, shown poor achievement of learning outcomes in Biology.

Integration of ICT in teaching Biology can enhance active learning. According to MOEST (2015), ICT integration is what can promote learning in today's world. Insufficient computers in schools and lack of training of teachers in IT have been major challenges facing the integration of computer technology into the instruction process. This notwithstanding, this study assessed the use of ICT integration in teaching and how it influences achievement of learning outcomes in Biology

2. LITERATURE REVIEW

Despite minimal use of ICT integration, studies have shown that ICT integration has contributed a great deal towards the achievement of learning outcomes. A study by Fernandes, Rodrigues, & Ferreira, (2019) demonstrated that ICT simulations significantly improved student's academic student in Biology compared to traditional teaching method. Simulations allow students to visualize complex biological concepts, making them more accessible and engaging. These tools provide interactive experiences that promote exploration and understanding. A study by Otieno, (2022) carried out in Kenya however showed that ICT integration was minimal in most schools in Rachuonyo South Sub County in Kenya. This finding is discouraging given that ICT integration is likely to lead to improvement in achievement of learning outcomes.

Another study by Karunakaran & Dhanawardana, (2023) in India, which aimed at identifying the level of ICT integration in teaching and learning process in the classroom, showed that most of the teachers use ICT in the teachers' room for their own work rather than implementing it in the classroom for teaching and learning. The results further showed that provision of ICT-based learning opportunities for students improve their learning quality. Similar findings in another study by Rind et al (2022) which investigated the effects of ICT integration on the students' academic achievement and retention in chemistry showed that information and communication technology positively affects students' academic achievement and retention when contrasted with conventional techniques of teaching.

In Pakistan, a study by Nayab et al, (2021) evaluated the use of Information and Communication Technologies (ICT)-based initiatives on students' academic achievements in terms of students' science scores. The results showed that ICT use has a positive as well as statistically significant impact on students' science learning. The results of the study also showed that students' level of interest toward learning science was enhanced by the use of ICT.

3. METHODOLOGY

This study employed a mixed methods approach, within an explanatory sequential design. It involved first collecting quantitative data, analyzing it and informed by the the findings to plan for collection of qualitative data. The systematic collection, analysis and integration of both quantitative and qualitative data helped in harnessing the complementary strengths of both quantitative and qualitative paradigms. This was suitable as implied by Creswell, (2011) who asserts mixed methods research offers a robust framework for attaining a more holistic and nuanced understanding of complex research problems.

In the first phase, quantitative data was collected using a questionnaire to capture quantifiable aspects of the phenomenon under investigation, including but not limited to the extent of achievement of learning outcomes; the teaching and learning process and the integration of Information Communication and Technology (ICT) in Biology teaching. The results gathered from the quantitative phase informed the design and implementation of the qualitative phase. In particular, the quantitative results guided the purposive selection of participants for in-depth qualitative phase and shaped the development of interview protocols, FGDs and observation guides.

The intent of the qualitative phase, was to deepen the comprehension of both the instructional processes involved in teaching Biology and the resultant learning outcomes interpreted as the 'product' of the teaching and learning process. Within these purposively selected sites, Biology lessons were systematically observed. The researcher also gathered data from key informants to capture their perspectives, interpretations and lived experiences related to the teaching and learning of Biology. In agreement with Gough and Deatrick (2015), the qualitative component emphasized not only the exploration of outcomes but also a rigorous investigation of the underlying processes

shaping those outcomes. Together, the sequential integration of quantitative breadth and qualitative depth enabled a more comprehensive and multi-faceted understanding on ICT integration in Biology teaching and its influence on learning outcomes.

The findings were presented as per the objective of the study where qualitative data explained concerns raised from the quantitative data. Data from the quantitative analysis was displayed in tables and graphs while data from the qualitative data was presented in a rich description thematically portraying more than one perspective of the themes.

4. FINDINGS AND DISCUSSION

Findings from the Quantitative Study on Use of ICT Integration in Biology Teaching

The teachers who participated in the survey were presented with nine statements. The first five depicted different ways of integrating ICT in teaching Biology and the other four based on why teachers do not use ICT. The teachers were asked to indicate whether they agree with the statements regarding integrating ICT in teaching Biology. The nine statements were:

ICTIBT1 Teachers encourage and allow learners to use digital tools such as computers, phones for further information/ research

ICTIBT2 Teachers use ICT in class to show biological processes in the classrooms.

ICTIBT3 Teachers use ICT to project notes for students.

ICTIBT4 Teachers keep and retrieve information records using ICT.

ICTIBT5 Teachers carry out assessment of learning with ease and speed using computer technology

ICTIBT6 Teachers do not use ICT due to lack of facilities

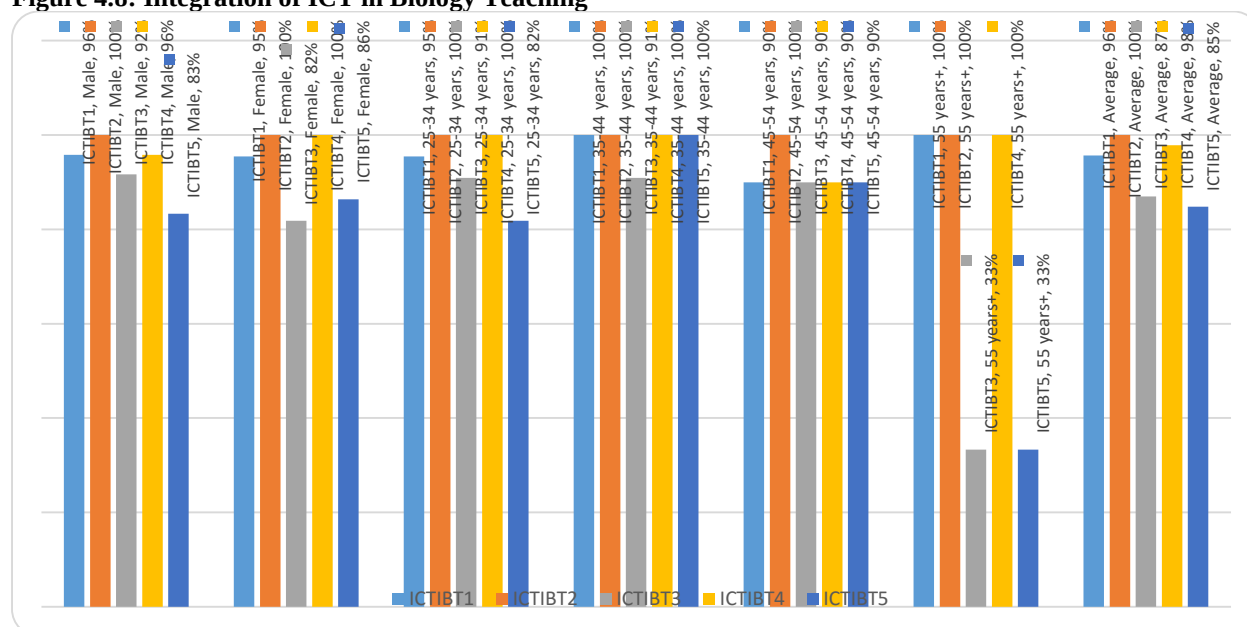
ICTIBT7 Teachers do not use ICT due to lack of training/know how

ICTIBT8 Teachers do not use ICT due to time constraints

ICTIBT9 Teachers, even though there is availability of time and ICT facilities, ignore to use ICT

Figure 4.8 shows responses on use of ICT by Biology Teachers.

Figure 4.8: Integration of ICT in Biology Teaching



All teachers who participated in the study agreed that teachers use ICT to show biological processes in the classroom. Most of the teachers (98%) agreed that Biology teachers keep and retrieve information records using ICT while 96% of the respondents agreed that they allow learners and encourage them to use digital tools such as computers and phones for further research. A good number, 87%, agree that teachers project notes for learners using ICT. Many teachers, 85%, agreed that teachers carry out assessments using ICT. These findings indicate that there Biology teachers acknowledge and agree with the integration of ICT as the teachers rated high various ways of ICT use ranging from 85%-100%. These findings concur with Mbatia, Wanjala, & Edome (2020) who state that many teachers in Kenya are open to incorporating ICT into their teaching methods. Teachers therefore recognized the potential of ICT integration in enhancing learning and improving information access.

Further analysis was carried out to find out if there were any significant correlations between the characteristics of the teacher namely gender, age and experience and ICT use.

Table 4.10 shows the correlation between the teacher characteristics and ICT use.

After establishing how ICT integration was happening in the selected schools, the researcher sought to establish how ICT use influences achievement of learning outcomes. With the quantitative approach, the teachers were asked in a scale of 1-5 (1 lowest and 5 highest) to indicate the extent to which various uses of ICT contribute to the achievement of learning outcomes. Table 4.12 shows the extent to which ICT integration contribute to achievement of learning outcomes.

Table 4.12: Extent ICT Integration Contributes to Achievement of Learning Outcomes

Rating		ICTIBTR1	ICTIBTR2	ICTIBTR3	ICTIBTR4	ICTIBTR5
Gender	Male	4.67	4.50	4.46	4.50	4.25
	Female	4.41	4.32	4.00	4.18	3.95
Age	25-34 years	4.68	4.45	4.27	4.45	4.23
	35-44 years	4.27	4.27	4.09	4.27	4.09
	45-54 years	4.60	4.60	4.50	4.50	4.10
Experience	55 years+	4.33	4.00	3.67	3.33	3.33
	4 years or less	4.50	4.38	4.13	4.13	4.25
	5-10 years	4.61	4.43	4.26	4.52	4.09
	11-15 years	4.00	4.00	4.00	4.00	3.80
	16-20 years	5.00	5.00	5.00	5.00	5.00
	21-25 years	4.75	4.75	4.50	4.50	4.25
	30 years and above	4.60	4.40	4.20	4.00	4.00
	Average	4.54	4.41	4.24	4.35	4.11

The Biology teachers who participated in the study across all genders, ages and years of teaching experience, on average, rated the ICT integration highly (4.11-4.54 out of 5) as considerably useful in contributing to the achievement of learning outcomes. Encouraging learners to use ICT such as phones was rated highest at 4.54, followed by use of ICT to demonstrate biological processes. Projection of notes and diagrams was rated at 4.35 while keeping and retrieving information was rated at 4.24. Use of ICT in assessment was rated at 4.11 which was the lowest compared to the rest. These findings agree with (Belay, Khatete & Mugo, 2020) who encourage use of ICT to engage students, enhance interactive learning experiences, improve information access and hence improve on achievement of learning outcomes. These findings show that many teachers recognized the usefulness of ICT integration even though, through class room observations and learners' FGD, minimal ICT use was witnessed. This implies that only a few learning outcomes may be achieved via the use of ICT in the schools under study and yet researchers have documented the huge impact of learning outcomes that can be attained if ICT was well used.

Findings from the Qualitative Study on Use of ICT Integration in Biology Teaching

From the qualitative approach, the researcher sought from the key informants on how ICT should be used by teachers in the teaching of Biology. The following is the response from key informant X:

KIQ: How do you advise teachers to integrate ICT in Biology teaching?

KI X

Most people think that ICT integration is computer; it is only one of the components of ICT. Information can be generated by any object and this information generated can be communicated in any way e.g. using a lap top, a phone etc. a computer cannot be used alone in ICT integration. A computer, a projector and a screen, those three form one technology in teaching and we call it a white board. A white board is made of three components. One must choose a technology and plan how they will infuse during teaching.

Even within one technology like the white board, there are several ways of application. A teacher can integrate their lessons with animations and simulations. Animation is taking whatever you are teaching which is static to be in motion for example. What do you know about animals? They move so if I was talking of a skeleton in animals they can see it moving in animation. When we talk of simulation we create a situation to look really in the eye of the learner. this is suitable for explaining processes like you can teach photosynthesis what happens in the leaf and how the food is manufactured and how it is transported and stored in areas using simulation. That is more encouraged than theoretically.

The key informant X informant indicated that many people do not understand what ICT integration means and that it actually means information generation and communication by use of any object not necessarily a computer and infusing it in the teaching process. The key informant X further indicated that ICT integration involves choosing a technology and planning to use it during teaching. This description of ICT integration by the key informant X agrees with Zaman, Ghosh, Majumder, & Chakraborty (2025) who note that ICT integration involves the intentional Utilization of technology to enhance teaching activities, promote student engagement and facilitate access to information. This means that lack of understanding of ICT use in the first place is a deterrent to proper use of ICT in teaching and learning Biology.

The key informant X further stated that a computer is often used with a projector and a screen to form one technology called a white board. The informant indicated that there are several ways of applying technology, one being animation. The key informant X said that animation is taking a static object and illustrating it to be in motion, for example, instead of teaching using a static skeleton the learners can instead see the skeleton moving in animation. Another way of ICT application is use of simulations. The key informant X described simulations as creating a situation to look real. Simulations are good in explaining processes such as photosynthesis and are much encouraged than theories. Thus, the key informant X noted that animation and simulations are ways of using ICT. These findings shed light on how ICT may be used to facilitate learning. However, from the earlier observations, none of these applications of ICT were displayed. The only two schools whose teachers were observed using ICT used it mainly for displaying videos and for learners to view diagrams.

On the same concern about how ICT should be used by teachers in the teaching of Biology, the key informant W said the following:

KIQ: How do you advise teachers to integrate ICT in Biology teaching?

KI W

They can do simulations in situations where they might not have the materials or some of the risky kind of experiments. We have shared with teachers the process of making nice ICT integrated lessons because it is not just a matter of showing videos and whatever. So we give them a matrix that we normally use with the teachers. I want to teach concept A. This concept A which digital and non-digital tools do I use? And in the same matrix you have to answer why do I need these resources? When do I use these resources in the lesson? When and where? Are you going to use it as a setter for engagement? Are you going to use it for them to explore and maybe gather some data and maybe explore and make conclusions? Are you going to use it to summarize the lesson? Or to assess learner's? So we have taken them through that and then to make your presentation.

Key informant W indicated that teachers may use ICT integration for simulations like in the case of risky experiments. The informant was categorical that ICT integration is not just a matter of showing videos but rather the teacher should make a good choice of technology whether digital or non-digital and when and where it should be used. He informed that ICT integration may be used as a setter for engagement; for the learners to explore and make conclusions or for assessment or making a presentation. These findings from both key informant W and X agree with (Admire & Patience, 2024) who document that use of Information, Communication Technology (ICT) in delivery of instruction such as simulations, learner engagement and exploration has a huge positive impact on learning. Use of ICT for the purposes outlined by the researchers and key informants was however lacking in the schools of study. This finding is discouraging given the positive impact ICT may bring in the learning of Biology. The researcher sought from learners through FGDs how their teachers use ICT integration. The following are some of the responses.

How do you and your teacher use ICT during the Biology lesson? School Q

R3: *The teacher projects videos for us to see.*

R5: *Also to view some complex diagrams.*

R1: *He has some questions in his lap top which he asks us*

In school Q, the learners mentioned that their teacher used ICT integration by projecting videos for them to see, displayed complex diagrams and stored some questions in his laptop which he asked during the lesson. Thus the teacher used ICT to engage and also to assess the learners, but on the two days the researcher visited the school, the teacher did not use any ICT integration during the teaching process.

In school T, the learners reported the following:

How do you and your teacher use ICT during the Biology lesson? School Q

R2: The teacher sometimes comes with the laptop and his phone but sometimes he can come with the projector and project it on the wall and it shows us videos. Then he asks us to discuss.

R4: The teacher comes with the phone and the laptop and uses it as a source of information for example if he is not sure about what is not in the text book to confirm if it's true or if it's false.

R6: The teacher prints something from the laptop and brings them to class during preps and tells us to do the questions.

The learners in school T indicated that their teacher used ICT integration to display videos and elicit a discussion, to refer to stored information and to assess the learners. On the day of visit, the researcher did not observe the teacher using ICT integration during the lesson.

In school R and S, the teachers used ICT in a similar way to display videos, to project questions with diagrams for learners to answer and also to project the notes. The learners in school R said the following:

How do you and your teacher use ICT during the Biology lesson?

School R

R3: The teacher projects videos for us to see and asks us to discuss.

R5: our teacher also displays some questions with diagrams.

R1: She displays for us some notes but we also add more notes from other textbooks

On the days the researcher visited the school, the teachers in school S and R were both utilizing the computer, the projector and screen in their ICT integration. The researcher observed the teacher in school R using ICT integration as follows:

Class observation: ICT integration: School R

The teacher used ICT to display Pictures of symptoms of diseases eg diarrhoea, vomiting for class discussion.

The teacher played a video describing causes, symptoms and control of cholera

The teacher displayed notes and questions for learners.

The teacher referred learners to use their phones or parents' phones to get more information but this should be done once they closed school as they were not allowed to have phones in school.

The teacher was knowledgeable in using ICT. She did not seek the help of a technician. She also kept time

The researcher observed the teacher use ICT integration to engage the learner in class discussion through display of pictures, videos, questions and notes. The teacher also referred the learners to use ICT integration at home to get more information on the concepts learned.

In school U and V, the learners said nothing about ICT integration. On the days the researchers visited the schools, the researcher did not observe any ICT integration taking place. These findings about ICT integration in the schools that were studied agree with a study by Otieno (2022) who showed that ICT integration is minimal in most schools in Kenya. This finding is discouraging given the exposure ICT integration may give learners more insight and help them have a better understanding of Biology.

Table 4.11: Correlation between the Teacher Characteristics and ICT use

		Correlations											
		Gender	Age	Experience	ICTIBT1	ICTIBT2	ICTIBT3	ICTIBT4	ICTIBT5	ICTIBT6	ICTIBT7	ICTIBT8	ICTIBT9
Gender	Pearson Correlation	1	.174	.088	-.009	. ^a	-.146	.143	.042	.210	.073	.109	-.124
	Sig. (2-tailed)		.248	.559	.951		.333	.344	.781	.162	.629	.471	.411
Age	N	46	46	46	46	46	46	46	46	46	46	46	46
	Pearson Correlation	.174	1	.834**	-.029	. ^a	-.252	-.174	-.119	-.298*	.022	.002	-.062
Experience	Sig. (2-tailed)	.248		.000	.850		.091	.248	.429	.044	.884	.989	.683
	N	46	46	46	46	46	46	46	46	46	46	46	46
	Pearson Correlation	.088	.834**	1	.092	. ^a	-.288	-.222	-.127	-.243	.098	.063	.089
	Sig. (2-tailed)	.559	.000		.543		.053	.138	.399	.104	.517	.679	.555
	N	46	46	46	46	46	46	46	46	46	46	46	46

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Among the nine statements, there was a significant correlation between age and ICTIBT6 use (Teachers do not use ICT due to lack of facilities). Younger teachers agreed that lack of ICT use is due to lack of facilities. These findings agree with the study of Admire & Patience (2024) who reveal that younger teachers are more likely to use ICT in their teaching than older teachers if the facilities are available. These findings show that with availability of ICT facilities many teachers especially the young may utilize ICT in teaching. It could also be because probably the younger teachers may have the knowhow of using ICT compared to older teachers.

5. CONCLUSION

ICT integration was rare in Biology teaching yet it was established that ICT integration helps learners achieve cognitive learning outcomes such as remembering, understanding and analysis; affective outcomes such as developing a positive attitude towards Biology; ICT integration for simulations and animations enable achievement of learning outcomes up to the analysis level and enhance students' positive attitudes. ICT integration by use of non-digital devices may promote skills outcome such as observation and experimentation

6. RECOMMENDATION

The Ministry of Education (MOE) working together with partners should provide and equip laboratories, libraries and computer rooms in schools. The institutions such as universities, Kenya Institute of Curriculum Development (KICD) and the Centre for Mathematics, Science and Technology Education in Africa CEMASTEA should organize for pre service and in service Training INSETs for teachers on ICT integration so as to enhance achievement of learning outcomes.

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