INTEGRATION OF ICT IN THE TEACHING OF BIOLOGY – A CASE OF SELECTED SECONDARY SCHOOLS IN MUMIAS SUB COUNTY

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Integration of technology in teaching and learning conforms to 21st century developments where global information is now readily accessible to the populace. Information communication and technology (ICT) is interactive and its non-linear properties highlighted by the hypertext techniques support the construction of knowledge. The hypertext method requires the renewal of the teaching techniques, the student being more active in their apprenticeship. This is in line with inductive method of teaching which is learner based unlike the deductive method where a teacher is the sole proprietor of knowledge in the classroom. This paper explores the extent to which ICT is integrated in teaching and learning in secondary schools in Mumias Sub-County to enhance Biology content delivery. The objectives of the study were to establish teachers ICT level, extent of ICT usage, support structures available for ICT usage, challenges faced by teachers in ICT integration in the teaching of Biology and strategies used by teachers to overcome the challenges. The rationale is based on the premises that use of ICT renders activity of the teacher more efficient, teacher-student relationship more lively and learning interesting. The study used descriptive survey design and was carried out in secondary schools in Mumias Sub-County-Kenya. The target population is 46 secondary schools. Stratified random sampling was used to select four counties and one private school that embrace ICT in their teaching and learning of Biology. This represents 10% of the schools in the Sub-County. Data was collected using questionnaires as the main instrument of data collection. Interview schedule for head teachers and classroom observation schedule was also used to give first hand information about ICT usage in the schools. Analysis of data was done using descriptive statistics and inferential statistics. Presentation was done by use of tables, percentages, charts, graphs and frequencies. The findings will exemplify what needs to be done in order to make teaching and learning of Biology more interesting and effective to enhance student performance in the subject.

Key words: Integration, Innovation, Pedagogy, INSET, Software, Hardware, Multimedia

Background and Rationale of Study

The 21st Century teachers have to cope with the advent of knowledge based economics that demand that they not only understand innovation but that they also increase their capacity to manage it (Cumming and Owen, 2006). The Innovative teaching and learning practices provide students with learning experiences that promote 21st Century skills characterized by knowledge building, problem solving, skilled communication, collaboration, self regulation and use of ICT for learning (Shear, L et al, 2009). Integration of ICT in teaching and learning is increasingly becoming an important agenda in educational reform initiative. The potential value of ICT in enhancing quality learning experiences and transformation of pedagogy are some of the factors driving ICT integration in teaching of Biology (Mc Nair and Galanouli; 2002).

With the advent of the World Wide Web there are now new tools and learning procedures that support development of such skills. Information Communication and Technology could prove to be advantageous in understanding of concepts in Biology because of their interactive and non-linear properties, highlighted by the hypertext technique that supports construction of knowledge. The educational reforms currently sweeping many countries in the world has
created enormous challenge, confronting the countries with the need to rethink their educational and social systems (Kozma, 2005). Instructions in Science in the 21st Century must be oriented to meet the challenges of covering the entire population in promoting scientific literacy. Biology, a component of science discipline is best taught by incorporating teaching and learning resources including ICT as media resource. ICT is an essential entity as it replaces essential passivity of students in class with an active learning mode stimulating interest, curiosity resulting in students’ involvement in the teaching and learning process. Biology teachers are the hubs in this endeavor and therefore a thorough understanding of the ICT integration in the subject is a pre-requisite to improvement in the instructional process. To be an effective innovative teacher, educational programs suitable to meet the exigencies of 21st Century has to be undertaken. According to Groove, J.W (2005) effective teachers are reflective practitioners who amplify the qualities of learning to inspire students and continuously critique the impact of their teaching colleagues and school community. Furthermore, the 21st Century teacher should understand learners’ pedagogical problem areas in taught subjects like Biology.

At the moment there is unprecedented amount of training at all educational levels on the use of technology in an effort to improve pedagogical teaching of difficult concepts in various subjects (Monteith, 2006). Moreover Darling Harmond (2006) advocates for adequate training of teachers in order to equip them with the 21st Century skills on “what and how” to teach knowledge thus enabling them to become adaptive experts who can continue to offer quality education. Boaduo (1988) and Lawal (2006) concurs but observes that no nation develops beyond the quality of its education system, which is highly dependent on the quality of its teachers. Teachers should acquire the most appropriate tools during training such as subject content, pedagogical methods and skills of knowledge transmission to be able to do their work professionally. Biology is an interconnected body of knowledge and teachers must motivate learners to make connections between knowledge and its application in life through improved pedagogical practice as science subjects are best taught and learned in the context of daily life, technology and community or society. Concepts are internalized through discovery and timely reinforcement of acquired knowledge. Robler and King (1988) consider an increase of approximately 10% in time for learning as an important gain when using computer applications such as computer-assisted instructions. To improve on pedagogical teaching of difficult topics, biology teachers need exposure to powerful conceptual frameworks to help them organize instructions and analyze classroom events otherwise they may fail to grasp new concepts about teaching and learning or they may learn them for the purpose of test, but revert to their perceptions later (Darling-Harmond and Bransford 2005). A well-versed and technologically sound teacher will create a culture of inquiry in his/her class. Today Biology students must be seen in a new context; first as facilitators, teachers must maintain students’ interest by helping them see how what they are learning will prepare them for life in the real world. Second, as collaborators in the learning process, instructors must instill curiosity in learners, which is fundamental to lifelong learning. Third, facilitators must act as partners in the learning process and be flexible in how they teach. Fourth, they must excite learners to become even more resourceful so that they can continue to learn outside the formal school system.

Concept of ICT

Information Communication and Technology (ICT) is commonly defined in Education as a diverse set of technology tools and resources used to communicate, create, disseminate, store and manage information (Brurton 2003). These technologies include computers, Internet, broadcasting technologies (Radio and Television), mobile (Telephony) digital cameras and software (such as E-mail discussion forums). The term ICT has had a long
history in the evolutionary process. According to Pelgrum and Law (2003), towards the end of 1980s the term computer was replaced by IT (information technology). This signified a shift of focus from computing technology to computer-enhanced capability to store and retrieve information. This was followed by the introduction of the term ‘ICT’ around 1992 when E-mail started becoming available to the general public. ICT according to Wikipedia is often used as an extended synonym for information technology (IT) but is a mode specific term that stresses the role of unified communication and the integration of telecommunication (telephone lines and wireless signals) computer as well as necessary enterprise.

Today the term ICT is applied to a set of technological tool and resources having immense potential to improve student-learning outcome when properly used (Wang, 2001). In the past ICT was viewed as presence of computer capable of facilitating mathematical and scientific tasks. In Kenya the difficult combinations of technologies are used rather than a computer as a sole delivery mechanism.

**Concept of ICT Integration in Teaching and Learning of Biology**

The potentiality of ICT tools are recognized in the role they play in accelerating the paradigm shift from traditional learning (teachers centered) to construction (students centered innovation) learning. According to Morton (1996) computer should not be seen as an addendum to content during pedagogical teaching. Such a view- he argues promotes the notion that computers like other traditional tools such as overhead projectors is added to the curriculum to enable curriculum developers continue implementing traditional subject based teacher--directed instructional plans where computer environment remains peripheral, an `add on` in space and time. Instead he suggests that technology is integrated when used in a seamless manner to support and extend curriculum objectives and engage students in meaningful learning.

According to Mutuma (2005) the use of ICT as part of the learning process can be subdivided into three different forms - Object, aspect or medium. As object, one refers to learning about ICT as specific courses like computer education, learners familiarize themselves with hardware and soft ware including packages such as Microsoft word, Microsoft excel and others. The aim of computer in this context is literacy. As aspect one refers to application of ICT in education, such as computer aided and manufacturing. Finally ICT is considered as a medium whenever they are used to support teaching and learning. In teaching ICT integration is considered both as an aspect and medium. The contemporary perspective according to Wekhaya (2010), Lack and Abrahams (2001) is in- cooperating ICT not as a separate entity but as a resource in pedagogical instructions. Integration therefore goes beyond computer literacy to include preparation, use, selection and operation of appropriate ICT materials in order to build knowledge as well as develop critical and creative thinking among students. Integration of ICT in the teaching and learning process is based on the principle that the linkage between content and methodology determines the learning outcome (Tony 1992). For effective integration of ICT in the teaching of Biology, teachers have to play a central role as intermediaries and use computer to fit into the curriculum and not the curriculum to fit into the computer. Integrating ICT into teaching and learning is not a new concept. Radios and Televisions have been used in the past under the banner of electronic media service to strengthen conceptual learning. Technology should be used not because it is available or it has been shown effective in some cases. It should be used to enable the process and enhance learning. ICT integration is therefore more of a process than a product as simple placement and/or software will not make integration naturally follow. (Eagle, 2002)

Integration focuses on how ICT is used and not simply whether it is used. Computers and Internet can be harnessed to improve the efficiency and effectiveness of teaching difficult topics in Biology. Application programs instructions (software) are usually used in a computer during ICT integration to accomplish tasks. When explaining nerve transmission
across a synapse in Biology, animations and simulations from installed software come handy. In a properly crafted ICT Integrated lesson ICT and pedagogy are molded into one entity. As a result the quality of the lesson realizes improvement in pedagogy. According to Karseti, and Larose (as cited in Wekhaya, 2010), Pedagogical integration of ICT in education is “use that permits either enhanced learning or enhanced teaching.

**ICT Integration in Teaching Around the World**

Academic activities that reflect the nature of high performance work groups in the 21st Century are being rekindled globally as learning activities extend beyond the traditional boundaries of the classroom fostering cross disciplinary connections and promoting global awareness and cultural understanding.

In Canada a project entitled “Computer Support International Learning Environment” (CSILE), was according to its author, the first system to offer a learning process based on collaboration between teachers and the students. The first version of the system goes back to 1986 and consists of a common database created by students and teachers via the Internet. The sharing of information between teachers and the students made collective knowledge of the class available to everyone, encouraging collaboration between the students in order to facilitate apprenticeship. This according Luc Guay (2007) conforms to 21st Century trends where knowledge is inductive, that is non-directive and based on experiments, explorations and spontaneous constructions carried out in micro-world which is displayed on a computer screen subjected to the requirement of the programs used. Deductive methods on the other hand have teachers directing the learning process through questions most of which are pitched on recall and comprehension and seldom at comparing, inferring, reasoning and evaluation.

Effectiveness of ICT in building knowledge and understanding was demonstrated in the United States of America in 1996 when the center for applied special technology (CAST) published results of a study carried out with 500 pupils in grades 4 and 6 in seven cities in the United States. According to Luc Guay (2007) half of the pupils had followed their courses of civil education through the Internet whereas the other half had followed them in the traditional way starting from the statement of their teachers using the handbook and their printed exercise books. The study showed that the pupils who had accessed the internet for the information retrieval, for the treatment of the new information and for the communication of their synthesis (experimental group) obtained much better results than those who had used technology (control group). Additionally four American research teams worked on didactical tools using ICT. The result of their work showed enhanced understanding of concepts by students and made it possible to believe that ICT represents very useful tool in the instructional process in all subjects including Biology (ibid p.13). Kinnaman (1990) observes that in America the number of schools owning computers increased from about 25% to virtually 100% between 1981 to the end of the decade.

In Brazil ICT has extensively been used to increase access to quality education (Gutterman et.al, 2009). The country’s national ICT policy makes it a requirement for institutions to integrate technology in education (Muyaka 2012). The country has adopted an education rate (e-rate) that ensures that the cost of connectivity is affordable for both institutions and citizens. It has also developed a center to train laboratory coordinators and teachers to ensure long-term success in the learning institutions) and also allow for teachers professional development (Gutterman, et.al. 2009).

Europe has developed a computerized teaching environment. The European council published in 1998 report widespread use of information technologies in improving teaching. The experiments presented in the report following a conference held in Finland set to answer questions as to whether ICT integration enhances learning. The number of students having access to ICT constitutes according to the report, a powerful motivation (Mars, 1998).
In Scotland most schools, colleges and other centers have put up effective infrastructure. In 2007 the government noted that almost all the institutions had access to broadband Internet connection (Government of Scotland 2009). Scotland ensures that integration of ICT in education starts with fundamental classes both pre-schools and primary institutions being provided with a wide range of ICT infrastructures. The country has upgraded the Internet supply moving to switch-based distribution arrangement capable of delivering data and application to the desktop at high speed. They have set aside devolved budgets for institutions to be able to procure equipment and software to meet the particular needs of the schools. All these practices of integrating ICT in supporting T/L show that a new relationship towards knowledge is progressively taking hold in the field in Europe and America.

Studies conducted by UNESCO (2007) in Asian countries indicate that ICT has the potential to help broaden access to education and improve teaching outcomes Waema (2005) considers the impact of ICT in education in India too great to be ignored crediting the sub-continent as having the largest scientific manpower in the world.


Njoroge (2007) quotes Wamukote, Angodi and Onguko (2010) in their study of integration of ICT in East Africa as recommending the need for teacher professional development (TPD) in the region to shift emphasis from acquisition of these skills for improved teaching and learning experience. He further states that TPD courses are essential to facilitate the acquisition of relevant teacher competence for effective ICT integration in class. This is done through “ACADEMIA” that offers programs to practicing graduate teachers drawn from the East African countries- Kenya, Uganda and Tanzania where participants are exposed to contemporary ways of Teaching and learning which includes ICT integration in pedagogical teaching of Biology. The graduates from ACADEMIA eventually form critical mass to ultimately facilitate the improvement of education towards standards in the region and facilitate professional development of other teachers in ICT integration.

Kenya’s long-term development blueprint (vision 2030) considers technology and innovation as one of the foundations in which three key pillars -Economic, social and political governance is anchored. The education sector is key to achieving the above vision. Integration of technology in the instructional process in Biology and other subjects has been undertaken to access quality information and arouse learners’ interest and curiosity. ICT became an education policy priority by the Ministry (Ministry of Education, 2006; Ministry of education and technology, 2005). The ICT options were based on Sessional paper No 1 of 2005 and Kenya Education support sector program (KESSP) paper and outlined among other priorities improving quality teaching and learning, improving educational policy and coordination considering costs and benefits of educational interventions. The options that were included in the Sessional paper and KESSP were:

1. Training.
2. Quality teaching and learning through ICT with focus on e-content development.
3. ICT ’s in teacher training colleges
4. Computers in secondary schools
5. Computers in primary schools cluster centers.
6. ICT for in-service teacher
The government of Kenya aims at achieving these goals by:

1. Promoting the development of an integrated e-learning curriculum to support ICT in education.
2. Facilitating public-private partnership to mobilize resources in order to support e-learning initiatives.
3. Promoting the development of content to address the educational needs of primary, secondary and tertiary institutions.
4. Creating awareness of the opportunities offered by ICT as educational tool to the education center.

On computer for secondary schools, the paper recognized the challenge of poor performance in Mathematics and Science and outlined potential benefits of ICT integration in enhancing greater critical thinking skills, scientific inquiry and analytical creative and collaborative power of computers. While recognizing the importance of ICT skills and computer studies, the paper observed the insufficiency of those skills in realizing full potential of ICT in education-creativity and collaboration, thus clearly called for integration of ICT in all subjects (SMASSE INSET, 2011).

The national ICT innovation and integration center (NIIC) was established in Kenya in 2011 and pioneer trainee teachers referred to as ‘champions’ were trained in the use of technology and specifically on integration of technology into classroom teaching and learning. In every constituency out of 210 constituencies, one ‘champion’ teacher had to be trained and he/she would in turn work with teachers in other secondary schools in the constituency to improve their ICT integration skills. The strategic objective for training was to build capacity for at least one teacher in each school to teach ICT, support ICT literacy and integration and help in basic maintenance of ICT equipment. Other than the ministry’s initiative of training a teacher in every constituency which has been successfully undertaken, SMASSE has been training subject trainers in mathematics, Biology, Chemistry and Physics in every District (now counties). The trainers train teachers in their subjects during holiday in-service education and training. The government went further to promote Kenya as an ICT destination within the region by establishing Kenya Information and Communication Technology Board (Kenya ICT Board). It was tasked with establishment of ICT infrastructure, encouraging competitive ICT industries in the country by developing, launching and driving a national system of innovation for Kenya. This would ensure creation of locally manufactured ICT infrastructure that support the local syllabi and content that would enhance use of ICT for teaching and learning in schools. After making it a priority to procure global Internet, in 2010 the government acquired undersea fiber links, which have provided global Internet to the country greatly reducing the delays and high costs that were associated with satellite links. The government however still identifies ICT hardware, software and connectivity as the three areas that are key pillars in providing ICT infrastructure for easier access (Kashorda, Acosta and Nyadiese, 2007). A number of collaborations with institutions like Universities and private ICT industry have been established by the Kenya government to assist in developing and assembling cheap personal computers. Other efforts by the government to encourage ICT integration include discussion with software vendors about software license cost to reduce Internet costs. Biology teachers will have to be masteries in content and pedagogical skills in order to offer quality instructions and realize improved performance in the subject.

Statement of the Problem

Constructivist approach to learning in the 21st Century requires learners to move from reproduction of information to construction of new knowledge. Consequently students must focus their activities on creativity, critical thinking, communication and collaboration to
unlock the Biology potential in them. The teacher’s role is increasingly being transformed from someone who imposes the memorizing of established knowledge to one who facilitates learners in their apprenticeship. Learning of Biology is expected to be concept based but quite often teaching and learning approaches used by teachers in teaching Biology tend to lean towards expository (transmission) than heuristic (discovery) methods. In the former knowledge is deductive- handed to learners while in the latter it is inductive- based on experiments, exploration and spontaneous construction. The outcome of the instructional process measured through evaluation in National KCSE Biology results has remained unsatisfactory.

National Biology results in the last five years (2009-2013) indicate that candidates underscored in all the three Biology papers—1, 2, 3 (Table 1). The marking reports from Kenya National Examination Council identified grey areas in the performances as description, explanation and “accounting for” questions. These areas according to Blooms taxonomy of instructural objectives borders on analysis, application and evaluation. Questions dealing with processes that describe working of organs are abstract and are poorly done. These sub-topic areas can be taught effectively using computer simulations and animations due to their abstract nature. Practical areas that required” accounting for” presence and absence of certain foods like reducing sugars, non-reducing sugars, proteins, starch, ascorbic acid and lipid were poorly done. These practical aspects require understanding of the concepts behind the activities, doing, observing and making conclusions and inferences. Students’ performance in Biology mock examination in Mumias sub-county has been poor more so in essay, compulsory questions and practical papers. Students however score averagely in paper one which is mainly structured.

KCSE Biology results in secondary schools in Mumias sub-county follow a similar worrying trend as the national one. The average mean grade in the subject for the last five years (2009-2013) has stabilized at C-.

<table>
<thead>
<tr>
<th>Year</th>
<th>Percentage score</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>P1- 20.14</td>
</tr>
<tr>
<td></td>
<td>P2- 18.41</td>
</tr>
<tr>
<td></td>
<td>P3-15.86</td>
</tr>
<tr>
<td>2010</td>
<td>P1-21.39</td>
</tr>
<tr>
<td></td>
<td>P2-18.67</td>
</tr>
<tr>
<td></td>
<td>P3-18.42</td>
</tr>
<tr>
<td>2011</td>
<td>P1-22.74</td>
</tr>
<tr>
<td></td>
<td>P2-23.31</td>
</tr>
<tr>
<td></td>
<td>P3-18.84</td>
</tr>
<tr>
<td>2012</td>
<td>P1-19.77</td>
</tr>
<tr>
<td></td>
<td>P2-20.70</td>
</tr>
<tr>
<td></td>
<td>P3-11.97</td>
</tr>
<tr>
<td>2013</td>
<td>P1-28.03</td>
</tr>
<tr>
<td></td>
<td>P2-22.36</td>
</tr>
<tr>
<td></td>
<td>P3-12.88</td>
</tr>
</tbody>
</table>

Source: KNEC

The three papers test different concepts. Paper 1 (231/1) consists mainly of low order testing skills questions (LOTS) and require recall and brief explanations. Paper 2 (231/2) has more comprehension. There are also compulsory data based questions and essay type descriptive questions. Paper 3 (231/3) is a practical paper that emphasizes analysis, synthesis and evaluation. They test manipulative skills apart from recall and comprehension.
It can be seen from table 1.1 that paper 1 was comparatively well done than paper 2 while paper 3 was poorly done. The result points out to the fact that learners are not doing well in high order testing skill questions (HOTS). These questions require understanding of concepts and constructivism on the part of the candidate. This is better achieved through improved pedagogical teaching methods. Table 2 shows mean and grade summary of Biology in the Sub County for the last five years giving insight of the examination results trend.

Table 2: Mean Scores in Biology (KCSE) in Mumias Sub-County

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean score</th>
<th>Mean grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>4.63</td>
<td>C-</td>
</tr>
<tr>
<td>2010</td>
<td>4.71</td>
<td>C-</td>
</tr>
<tr>
<td>2011</td>
<td>5.92</td>
<td>C</td>
</tr>
<tr>
<td>2012</td>
<td>4.63</td>
<td>C</td>
</tr>
<tr>
<td>2013</td>
<td>6.39</td>
<td>C</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>5.25</td>
<td>C-</td>
</tr>
</tbody>
</table>

Source: DEO’S Office Mumias

The slight improvement in subject means between 2009 and 2011 could be attributed to many in-service workshops increasingly being carried out by SMASSE that includes ICT integration. The mean scores and grades are still low pointing to the need to improve pedagogy.

**Purpose of Study**

The purpose of this study is to explore and determine the impact of ICT integration in enhancing pedagogical teaching of Biology in Secondary schools in Mumias Sub-County. In the process of ICT integration the instructor takes cognizance of the potential of ICT tools in enhancing participatory pedagogies. In particular this study endeavors to determine how ICT integration in teaching of Biology enhances learning process.

**Objectives of the Study**

The objectives of the study will be to:

1. Investigate teachers’ preparedness in integrating ICT in pedagogical teaching of Biology Identify: (a) ICT tools (b) methods, and (c) process of ICT integration in pedagogical teaching of Biology
2. Identify the challenges experienced by teachers in ICT integration during pedagogical teaching of Biology
3. Find out strategies employed by teachers in overcoming the challenges of Integrating ICT in pedagogical teaching of Biology

**Research Questions**

The research questions below were formulated by the researchers to guide the study:

1. What is the level of preparedness of Biology teachers in Secondary schools in the Sub-county in integrating ICT in the pedagogical teaching of Biology?
2. Which (a) ICT tools, (b) methods of ICT integration, (c) processes of ICT integration are-used by Biology teachers in pedagogical teaching?
3. What challenges are experienced by Biology teachers in the integration of ICT in the teaching of the subject?
4. What strategies are employed by Biology teachers in overcoming the challenges of Inco-operating ICT in pedagogical teaching of the subject?

Theoretical Framework

This study is modeled on system theory by Ludwig Von Bestalanffy (1928) advanced by Kate and Kahn (1966). According to this theory a system is a collection of interrelated parts, which form some whole. This theory was preferred over neo-classical organizations theory which the researcher felt cannot suffice because of their emphasis of schools as fragmented and closed social units independent of external force (Backer, 1973). System theory mentions two types of systems-closed and open systems. Closed systems are self-supporting and do not interact with the environment. Open system on the other hand interacts with the environment on which they rely on obtaining essential inputs and discharging of outputs (Kate and Kahn 1966). Cole (1993) a proponent of system theory asserts that there is a great interdependence between the system and the environment and further says that if anything goes wrong in the environment or any of the sub systems the other systems will be affected and this will affect the output.

Schools are managed more like systems where educational programs are innovated and re-innovated to realize the importance each part makes to the whole, and the necessity of eliminating the parts that make negative contributions. Biological Science Department can be considered as a sub-system within the school. The school has other systems like administration that may support ICT integration by purchasing computers and laying infrastructure, finance and procurement, discipline, guidance and counseling and many others. Improvement in the pedagogical teaching and resultant good performance in Biology is part of the output measured through formative and summative evaluations respectively. The output is therefore affected not only by what goes on in the Biological science classroom like instructional methods but also in other departments like finance, procurement and discipline that is concerned with availing and effective use of the resources. Due to these interactions, schools are better studied as a whole rather than parts. System theory postulates that schools are like open systems which of necessity engage in various modes of exchanges with the environment (Katz and Khan, 1966). The environment includes the community in which the schools are located and from which the learners and teachers are drawn. This entails the social, cultural, physical, climatic, economic and even political aspects such as Educational policies.

Conceptual Framework

There are variables that interact to influence the quality of pedagogical instructions the learner receives. These are independent and dependent variables. In this study, it is implied that incorporation of technology in the teachers’ pedagogical teaching methods are the independent variables which influence outcomes that is quality of instruction which is improvement in pedagogical teaching. This qualitative aspect can be observed by the interest and participation that learners show during lessons that should naturally lead to improved performance. Improvement in pedagogical teaching is the dependent variable as it depends on the independent variable (ICT integration in pedagogical teaching). There are extraneous variables that affect the outcome of teaching. These are institutional factors like ICT policy of the schools, support structures and technical support. If these are positive then improvement in pedagogical teaching and resultant good performance by students will be realized. There
are special extraneous variables called intervening variables, which are related to the independent variables that can shift the outcome (pedagogical teaching) to the positive or negative. These variables include perception, curiosity, interest, competence and attitude of learners and determine the direction of outcome. These students’ factors are what the researcher describes as intervening variables. Improvement of pedagogical teaching of difficult topics in classroom can be realized by applying proper pedagogical practices.

Figure 1: How ICT Integration Affects Learning Process

In the conceptual framework depicted in Fig 1, ICT integration is hypothesized to influence pedagogical teaching of difficult topics in Biology. The framework postulates that the status of ICT integration (independent variable) in pedagogical teaching of Biology affects the quality of teaching realized by improvement of pedagogical teaching (dependent variable). However this relationship may be modified due to students’ factors like perception, curiosity, interest, competence and attitude (intervening variables). These intervening factors are caused by independent variables (ICT integration in pedagogical teaching of difficult topics in Biology) and affects dependent variable (improvement in pedagogical teaching of difficult topics). Extraneous variables like ICT policy, management support and technical support although not caused by independent variable affect the dependent variables.

Research Design

This study was conducted through descriptive study using survey design. Descriptive studies describe the state of affairs as they exist (Kerlinger, 1973). Survey designs provide numeric descriptions of some part of the population- representative sample from which a pointer to the population trend is established (Bell, 1993). Descriptive survey design enabled the researcher to obtain information on the state of ICT integration in the pedagogical teaching of Biology in secondary schools in Mumias Sub county by accessing opinions of students, teachers, head of Biological Science departments and Principals of the schools to assess the effects such integration has on pedagogical teaching of the topics (Best & Kahn, 1992). The approach to the study was both quantitative and qualitative.
Target Population

The target population consisted of all 49 secondary schools in Mumias Sub-county having 14934 students, 497 teachers and 49 head teachers. Out of these, 45 are public schools and 4 are private schools. County, some private and sub-County secondary schools in the sub county are endowed with ICT resource tools for pedagogical teaching. The researcher therefore felt that selecting 4 County schools and one private school would provide a reliable picture of ICT integration in schools in the sub-county.

Sampling Techniques

The researcher selected 5 schools from a sampling frame of 49 schools selected through stratified sampling. This being a finite universe the researcher employed a sampling technique that could minimize bias in sample selection while at the same time being representative of the population. Two forms of probability sampling- stratified random sampling and simple random sampling were used to put schools into three categories- County schools, Sub-county schools and private schools. Four County schools and one private school were selected through random sampling. Teachers and student respondents were purposively or randomly selected in the schools while the Head teacher of the schools were selected for interview.

Sample of students. After selecting the 5 secondary schools, a stream in forms 1,2,3 and 4 was randomly selected for the purpose of administering student questionnaire. Ten percent of students (5) in a chosen stream of a class were sampled for study. Where there was single sex systematic sampling was applied. Admission numbers were used where students were present in schools. Admission register was used to obtain student admission numbers. Where both boys and girls were present the researcher strove to strike gender balance by employing stratified sampling method to separate boys and girls and thereafter get 10% of either sex through systematic random sampling. A total of 100 students from the schools were selected for study.

Sample of teachers. A biology teacher in every school teaching a cross section of biology classes was selected through random sampling unless he/she was the only biology teacher. The most experienced teacher was purposively sampled where there was more than one Biology teacher.

Sample of Head teachers. One Head teacher from each of the five chosen schools was subjected to an interview by the researcher. Head teachers from the three pilot schools were also interviewed. The researcher interviewed all of the eight Head teachers.

Determination of Sample Size

A sample is part of the target (or accessible) population that has been procedurally selected to represent it. It is any number of cases less than the total number of cases from which it is drawn (Ingule & Gatumu, 1996). The sample consisted of 5 secondary schools selected from 49 secondary schools in the sub-county. This represents 10% of the total number of secondary schools in the district. The sample size of students will be 10% of the number of chosen students in a class. The Head teachers of each of the sampled schools will be interviewed.
Table 3: Sample Grid for all Item Categories

<table>
<thead>
<tr>
<th>Item</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Sec schools in Mumias sub-county</td>
<td>49</td>
</tr>
<tr>
<td>Selected schools</td>
<td>5</td>
</tr>
<tr>
<td>Pilot schools</td>
<td>2</td>
</tr>
<tr>
<td>Head teachers selected</td>
<td>5</td>
</tr>
<tr>
<td>Biology teachers sampled</td>
<td>5</td>
</tr>
<tr>
<td>HoD’S Biology</td>
<td>5</td>
</tr>
<tr>
<td>Total number of students in sub- county</td>
<td>14697</td>
</tr>
<tr>
<td>Sampled Biology students in 5 schools</td>
<td>2972</td>
</tr>
</tbody>
</table>

The total number of students in sampled schools (2972) represents 20% of the total number of students (14,697) in the Sub-County. This according to Cohen and Manion (1994) is representative and acceptable in survey as it represents acceptable percentage range (20-30%) of the target population under study.

Construction of Research Instruments

The researcher used Questionnaires and interview schedule as the main instruments for data collection. The researcher was mainly concerned with views, opinions, perceptions, feelings and attitudes. Such information can best be collected through the use of questionnaires and interview schedules (Bell, 1993; Touliatos & Compton, 1988). Questionnaires for teacher, Students and Heads of department were semi-structured. This enabled the researcher to balance between the quantity and quality of data collected and on the other hand provides more information useful for a fuller explanation of the phenomena under investigation. Observation schedule was deployed to observe live lesson taught using ICT integration and students’ responses.

Questionnaires

The researcher employed questionnaires for students, teachers and Heads of Biology departments. The semi-structured questionnaires gave respondents greater chance of expressing their views, ideas, opinions and suggestions on ICT integration. Quantitative and qualitative data was collected through the questionnaires developed by the researcher and modified by experienced teachers after undergoing Pilot study. Data from teachers questionnaires was used to cross check and supplement information provided by students on ICT integration. The questionnaires were administered by the researcher and research assistant working under researchers’ instructions. The heads of departments’ supplemented information given by teachers and provided overall picture of ICT integration in all classes taught by various teachers. Student questionnaires had three sections A, B and C. Section A dwelt on personal information, section B on preparedness of students in learning through ICT integration while section C was on ICT tools, integration process, challenges in the use of ICT integration in T/L and possible solution to the challenges. Teachers and HoD’s questionnaire followed the same format but ‘learning’ had been replaced by ‘teaching.’

Interview schedules. Interview schedules-for Head teacher was used to collect information pertaining to the use of ICT in the schools in terms of availability, usage, challenges in usage, improvement in ICT infrastructure and training. Bode and Henry (1983)
state that interviewing is an appropriate instrument for any study as it helps the interviewer to cover all the dimensions of the investigations through probing of the respondents

**Observation schedule.** Lesson observation schedule was used by the researcher to confirm ICT integration in classroom. Two schools were selected for observation. Observation schedule was used to verify ICT resources/tools used, their relevance to the chosen sub-topic taught, integration process in terms of synchronization of resource and content blending in the pedagogical teach

Confirmation of availability of ICT tools for integration is important since you cannot use what is not there. The working condition of computers and various software and hardware affect pedagogical teaching of Biology. The researcher gained firsthand experience without informants’ on the state of ICT in schools. Observation helped bridge the gap between what people say they do and what they actually do based on what is there and used. The researcher sought to observe ICT tools, infrastructure, storage, usability and their state.

**Pilot Study**

The researcher conducted a pilot study before commencing the main research. The purpose of the pilot study was to pretest the instruments on a small sample of respondents before commencing the actual research work. Pilot studies helped identify and rectify mistakes prior to use in actual research work. Piloting was done in two schools- one County and private school. Two Head teachers, two teachers and 40 students were used to pre-test interview schedule, teachers and students questionnaires. Observation schedule similarly tested and improved in the chosen school. The researcher used the findings from the pilot study to validate.

**Table 4: Schools Chosen for Pilot Study**

<table>
<thead>
<tr>
<th>Name of school</th>
<th>Type</th>
<th>Category</th>
<th>Division</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mumias Girls Muslim</td>
<td>County</td>
<td>Girls Boarding</td>
<td>Mumias</td>
</tr>
<tr>
<td>Rehema Academy</td>
<td>Private</td>
<td>Mixed Day</td>
<td>Mumias Central</td>
</tr>
</tbody>
</table>

Source: Researcher (2015)

In the above schools selected for pilot study a quarter (10%) of student in the class or stream was chosen by random sampling and systematically administered by questionnaire. For single streamed school form one to four classes were administered with questionnaire while Biology teacher/s were purposively or randomly sampled for pilot study

**Validity of Instrument**

A valid instrument accurately measures what it is supposed to measure (Bennars & Otiende, 1994). According to Mugenda and Mugenda (2003), an instrument that yields valid data will necessarily yield valid information. The validity of the instrument was determined by using long serving teachers in the district to judge how well the measuring instruments met standards through content (content validity). The instruments appearance – showing genuine features was checked to ensure originality (face validity). Comparison of the outcome of the prevailing conditions with the predicted outcome was made and correction made (criterion related validity). Experienced teachers in the county ascertained construct validity during construction of instrument by presenting it for review during piloting. The researcher also ensured that the scores from instrument accurately predicted a criterion measure by making amendments (predictive validity). Finally the results obtained using instrument was checked if they correctly correlate with other results (concurrent validity) and amendments made to
make it valid. To establish validity, the instrument was given to two experts to evaluate the relevance of each item in the instrument to the objectives and rate each item on the scale of very relevant (4), quite relevant (3), somewhat relevant (2) and not relevant (1). Validity was determined using content validity index (CVI). CVI = items rated 3 or 4 by both judges divided by the total numbers of items in the questionnaire. This is symbolized by n3/4/N. A coefficient of 0.80 or more will imply that the instrument is highly valid.

**Reliability of Instrument**

Reliability can be defined as the degree of consistency between the measures of the same kind. Kothari (2005) defines reliable instrument as that instrument that provides consistent results. The researcher ensured that responses from respondents are consistent across variables through testing and retesting the questionnaires. Students of the same class level and streams were used to ensure that the individuals do not vary their responses if the instruments were to be administered a second time (stability). Colleagues were encouraged to administer a copy of the same questionnaires to students and rectifications were made to ensure that errors made during administration or scoring of instruments is eliminated. The colleagues’ scores were compared with the result obtained by using researcher’s questionnaire (equivalent aspect) to enable rectification to be made. The instruments was piloted in the schools which were not be included in the study sample and modified to improve their reliability coefficients to at least 0.70. According to Kathuri & Pals, (1993) coefficients of at least 0.70 are acceptable as valid and reliable in research. Reliability involves formulating the main instrument - student and teachers questionnaires by splitting them into two halves, odd and even with items sampled from the main domain of indicators measuring variables. Respondents score in one part will be correlated with scores from the second part using the formula:

\[ Rx = \frac{\sigma^2}{\sigma^2_x} \]  

**Data Collection Technique**

The researcher sought permission to conduct research from Head teachers of Schools and later used the privilege to interview the Principals and administer questionnaire to teachers, HODs and Students. The data was collected using questionnaires and Interview schedule. The researcher visited the schools under study before the start of research to familiarize with respondents and request for their cooperation made.

**Data Analysis Procedures**

Analysis is the computation of certain indices or measures along with searching for patterns of relationship that exists among the data group (Kothari, 2005). Since open-ended items were included in the semi structured questionnaire qualitative or non-empirical data generated required qualitative and quantitative techniques of data analysis.

**Data Analysis from Questionnaires**

Raw data obtained from the field using questionnaires for teachers and students were organized and edited for errors and omissions. Data were separated into consistent component parts or elements separately and in relation to the whole. Data were then coded by assigning numerals and other symbols so that responses can be put into limited categories. It was important because the data was mainly descriptive hence requiring translation from qualitative to quantitative forms. After coding data was classified by arranging them into groups or classes to reduce the large volume and put them into homogenous groups to get meaningful relationship. They were then be analyzed by aid of statistical package for social science (SPSS) using descriptive statistics. Frequencies and percentages were mainly be used. Tabulation of the results was done by arranging same kind of data in a concise and logical manner to help answer research questions.
**Interview schedule.** Data collected through interview with school Head teachers and QASO was qualitative. A personal interview in the form of personal investigation was carried out in a structured manner. Raw data from interview records underwent coding and classification.

**Classroom observation schedule.** Data that was obtained from observation using classroom observation schedule took into account teachers and students activity. Two different schedules; one used in a class where ICT integration was employed in pedagogical teaching of Biology and the other one where conventional teaching method is employed without ICT use was employed. The researcher observed the learning process in both teacher and learner.

**Logistical and Ethical Considerations**

These are considerations that may hinder the researcher obtaining accurate information (Mugenda and Mugenda, 2003). Logistics refers to all those processes, activities or actions that the researcher must address or carry out to ensure successful completion of research work. The major ethical problem in this study is the privacy and confidentiality of the respondents. Obtaining valid sample entailed gaining access to specific lists and files which itself is an infringement on the privacy and confidentiality of respondents. Without this, construction of sample frame and generation of representative samples would be difficult. The solution to this problem is the respondents ignoring items they do not wish to respond to. Apart from the fieldwork logistics, there is pre-field and post-fieldwork logistics. Pre-field work logistics included establishing work plan, obtaining permit and construction and pre-testing instruments. These are done with a lot of humility and courtesy. In post-fieldwork logistics, analysis requires honesty and sacrifice. Cohen and Manion (1994) state that the researcher should take appropriate precaution to protect confidentiality of both respondent and data.

**Summary**

This discussion was designed to generate data on improvement of pedagogical teaching of topics in Biology through ICT integration. The research was designed to generate both quantitative and qualitative data. The instruments used for this purpose - namely, questionnaires, interview schedule, classroom observations schedule. The target population was 49 secondary schools in Mumias sub-county. A drawn sample of 5 schools representing 10% of the target population was used. All classes – form one to four were involved in the study with purposive sampling used to select a stream in each class. Teachers were purposively and randomly sampled depending on whether they were teaching the classes with experienced colleagues or not. The Head teachers of all the 13 schools together with HOD’s of Biological science were selected for study. Interview schedule helped confirm the findings from teachers and HOD’s. The choice of a small target population, right tools and minimization of extraneous variables through random sampling, it is believed helped result into successful research finding.

**Research Findings and Discussion**

**Objective one:** *Teacher preparedness for ICT Integration in the teaching of Biology.*

Research investigation into preparedness of Biology teachers in integrating technology into their teaching revealed that teachers are ICT literate having attained Certificate or Diploma in Computer training. Their students were equally computer literate with students in town schools showing high rate of literacy than students in rural schools (Table 5)
Table 5: ICT Literacy Level in Teachers and Students

<table>
<thead>
<tr>
<th>Respondents</th>
<th>Number (N)</th>
<th>ICT Literate</th>
<th>ICT Illiterate</th>
<th>Percentage Literacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology teachers</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Students</td>
<td>100</td>
<td>71</td>
<td>29</td>
<td>71</td>
</tr>
</tbody>
</table>

It was however revealed that Schools in the urban area (Mumias Central) had 83% student literacy level compared to schools in the rural setting (27%). Teachers showed high rate of literacy and academic qualification. Such qualification and literacy is expected to naturally translate into high levels of ICT Integration in pedagogical teaching of Biology.

Table 6: Qualifications of Teachers

<table>
<thead>
<tr>
<th>Respondents</th>
<th>Number (N)</th>
<th>Academic Qualifications</th>
<th>ICT QUALIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Certificate:Diploma:Degree</td>
<td>Certificate:Diploma:Degree</td>
</tr>
<tr>
<td>Biology Teachers</td>
<td>5</td>
<td>-----</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-----</td>
</tr>
<tr>
<td>Head of Departments</td>
<td>5</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-----</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>-----</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-----</td>
</tr>
</tbody>
</table>

In addition to their academic and computer literacy, most of the teachers attend workshops on ICT integration once a year. Despite these advantages majority of Biology teachers do not integrate technology in their teachings as can be observed from the findings in the table below.
Table 7: Do Biology Teachers Integrate ICT in their Teaching

<table>
<thead>
<tr>
<th>Respondents</th>
<th>Number (N)</th>
<th>YES Weekly:Termly:Yearly</th>
<th>Not at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>100</td>
<td>49:12:4</td>
<td>35</td>
</tr>
<tr>
<td>Teachers</td>
<td>5</td>
<td>1</td>
<td>1:2</td>
</tr>
<tr>
<td>HOD</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Principals</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 5 shows that the level of ICT integration remains low even with high level of literacy in both teachers and students. Most teachers are youthful and within the age group of 25-34 (80%) according to the research finding. They are expected to spearhead ICT integration but that is not the case. The table also shows that HODs and Principals believe teachers are frequently integrating ICT in their lessons weekly but both teachers and learners say they rarely do. Human factors affecting adoption of technology in teaching are attitudes, perception, competences and self-efficacy. Human factors may be barriers to both preparation of teacher and even ICT implementation. Galanouli and McNair (2001) indicate that individual teacher’s attitude is crucial in determining whether the teacher will integrate ICT. Other human factors like lack of confidence in using ICT, resistance to change, negative attitude towards ICT and lack of perceived benefits are among consistent barriers to teacher integration of ICTs (Becta 2004). Edooley (2000) as cited by Gakuu (2006) states that the way people perceive and react to technology is far more important than technological obstacles in influencing ICT implementation and use.

**Objective 2:** ICT tools, methods and process of integration. Secondary Schools in Mumias sub-county are endowed with ICT resources that can make a difference in Biology performance if properly utilized. The table below gives the schools ICT position.

Table 8: Respondents View on ICT Tools Available in the Schools

<table>
<thead>
<tr>
<th>ICT TOOL</th>
<th>STUDENTS</th>
<th>TEACHERS</th>
<th>HODs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer</td>
<td>78</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Radio</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Mobile phones</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Digital Camera</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Television</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Internet</td>
<td>-</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Interactive white board</td>
<td>21</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Computers were the main ICT tools found in the secondary schools under study according to students (78%), teachers (100%) and HODs (80%). Interactive whiteboard is making a strong entry into an otherwise blackboard/Black wall dominated classroom. Mobile phones are universally owned by citizens but since they are prohibited in schools students did not mention them as an available ICT tool. Digital Cameras are now readily available in every school. Televisions are still a source of learning especially on Ecology. Connections can also be made to the screen via external devices. Radio lessons that used to be aired through electronic media service are no longer dependable. When asked how useful computers are in ICT integration respondents gave the responses captured in Table 9 below:

\[\text{Table 9: Importance of Computer in Teaching and Learning}\]

<table>
<thead>
<tr>
<th>Response</th>
<th>Stimulate interest</th>
<th>Arouse curiosity</th>
<th>Enhance syllabus coverage</th>
<th>Enhance Understanding of concepts</th>
<th>Access Quality information</th>
<th>Communicate With remote groups</th>
<th>Receive Feedback Outside classroom</th>
<th>Help participate in democratic process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>21</td>
<td>9</td>
<td>3</td>
<td>49</td>
<td>42</td>
<td>4</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Teachers</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HODs</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Teachers need support to ensure ICT integration takes root in teaching of Biology. In two schools sampled teacher respondents (40%) felt the schools were giving necessary support by loading Internet to enhance students and teachers’ research work and also servicing computers regularly. Majority of teachers (60%) however felt there was no enough support by the institutions to support ICT integration. The institutional factors like management and technical support play an important role in general preparedness of a Biology teacher to embrace and integrate ICT in the teaching of Biology. William Green et al (1997) contends that culture developed within an institution or within an organization can act as a barrier to change. In order for new technology to be placed in an organizational culture, there must be a match of organization and Technology (Hodas 1993). Kara (2008) suggests that management of ICT should involve two levels: Strategic level which involves reviewing and putting in place the most appropriate way of exploiting ICT, sourcing and using new ICT as needed by the organization and Operational level which involves providing high quality, reliable, capacity building, delivery implementation and application as well as monitoring usage and effectiveness.

**Objective 2b**: Methods of ICT integration. Methods of ICT integration involve Topic (meso) level and Lesson (micro) level. CDs and DVDs containing topics and sub-topics are run. The researcher who was watching a lesson on blood flow through the heart observed the animations and simulations. The topic was Transport in animals (meso) while the lesson was ‘Pumping mechanism of the heart’ (micro). Table 2.5 shows that students use computer during learning process where it is integrated in the lesson to demystify difficult topics (49%) and also to access information through the net (42%). It may also happen at Curriculum (macro) level when students watch wildlife film. This is a case of cross-curricular integration method.
**Objective 2c:** Process of ICT integration. The process of integration is **enactive/manipulative, iconic and symbolic** representation. These steps or stages constitute the process of ICT integration in a lesson. According to Jerome Brunner (http://tip.psychology.org/brunes.html) there are three critical stages in ICT integration process that are necessary for effective teaching and learning and teachers need the skills to make a seamless combination and integration of the three stages. These stages are: 

(a) **Enactive/manipulative:** In this stage students need to do or experience something like solid, gas, liquid. Students’ personal interest develops through concretization of the realia. Generalizations of the characteristics are given. Exhibits and contrived experience take precedence. 

(b) **Iconic representation:** Richer representations of what is being taught are needed. Diagrams, photographs and other visuals that aid learning are used to enhance understanding of difficult concepts. This stage involves adding complexity to the lesson to connect between concrete (a) and abstract (c). 

(c) **Symbolic representation:** Clear explanations are needed from the teacher about abstract concepts. Questions can be asked by the teacher to test understanding of the concepts. This step is interactive and recycling mode is frequently used to revisit concrete stage or enactive stage. ICT can never replace the enactive step. It is always important for a student to have a real hand on experience. The student will gain understanding through experience. In most lessons iconic stage is either left out or is not well represented and that is where ICT can come in handy to fill the gap. The table below from research findings shows that students are not using manipulative skills to access knowledge as expected.

<table>
<thead>
<tr>
<th>No of students (N)</th>
<th>Taking computer as a subject</th>
<th>Not taking computer as a subject</th>
<th>Exposed to computer at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>69</td>
<td>31</td>
<td>54</td>
</tr>
</tbody>
</table>

Table 10 shows that out of 69 students taking computer only 54 feel they are being exposed to computer as expected. All 39 students not taking computer together with five taking computer studies feel they are not exposed enough to it. The figure below represents the integration process of a pedagogical taught lesson in Biology - DNA replication.

**Figure 2: Process of ICT Integration in a Biology Lesson (Micro)**
Stage 1 is preceded by what is called Ice breaking in pedagogical term that is, a teacher applies pedagogical principles of bridging hence connecting the previous lesson with the present. In the case of DNA Replication, the teacher would revisit components of DNA like 5 carbon sugar, Nitrogen bases, and phosphate and understand base-sugar sequence and genes represented by a nucleotide. In stage 1 student would physically identify the sugars, Nitrogen bases, phosphate molecules and observe representation for bonds within Nitrogen bases.

A teacher uses a drawn chart, diagram or picture to give a two dimensional representation of DNA double helix in a drawing or picture in stage 2. Stage 3 introduces abstractions. Since replication of DNA is an abstract concept. Animation or simulations can be used to integrate pedagogical teaching with ICT to improve pedagogical teaching of these abstract concepts. Orlich (2001) states that students learn better where instructional activities are sequenced that is knowledge is presented in a carefully interrelated steps generally starting from simple step, add complexity and lastly introduce abstractions. ICT integration helps in understanding difficult abstract concepts in this hierarchy of learning.

Objective 3: Challenges faced by teachers in ICT integration. Teachers face many challenges in ICT integration in the classroom. These may be human, institutional or personal.

<table>
<thead>
<tr>
<th>Respondents</th>
<th>Cost of computer</th>
<th>Absence of power</th>
<th>Frequent power failures</th>
<th>Cost of Dvds</th>
<th>Cost of Antivirus</th>
<th>Unavailability of tech services</th>
<th>Cost of Accessories</th>
<th>Lack of Qualified teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td>---</td>
<td>---</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>%</td>
<td>-</td>
<td>-</td>
<td>60</td>
<td>20</td>
<td>20</td>
<td>60</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>Students</td>
<td>20</td>
<td>39</td>
<td>--</td>
<td>--</td>
<td>30</td>
<td>--</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>%</td>
<td>20</td>
<td>39</td>
<td>--</td>
<td>--</td>
<td>30</td>
<td>--</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>HOD</td>
<td>3</td>
<td>2</td>
<td>--</td>
<td>--</td>
<td>30</td>
<td>1</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>%</td>
<td>60</td>
<td>40</td>
<td>--</td>
<td>--</td>
<td>30</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Several factors, mainly socio-economic tend to impede ICT integration in the teaching of various subjects including Biology in schools. Such factors render ICT integration ineffective or even impossible. These factors include infrastructure, ICT support system, costs and usage. **Infrastructure**

In Africa, inadequate ICT infrastructure is commonly cited as a major hindering factor toward ICT integration (Urwin, 2005). The transmission channels, media and communication must be able to support information relay. Various parts of Kenya are not connected to the Internet or if connected there maybe some outage on connectivity which makes it difficult to
connect to online content. To ease the problem of connectivity teachers ought to back up a copy of the content on a computer or any other storage media so that it can be used where there is a problem with the Internet. A teacher is also forced to print hard copy of content when Internet is not available.

**Cost Factor**

Computers and technological infrastructure are expensive. Furthermore user licenses for various devices that support ICT integration must be purchased together with complimentary software. Provision of computers in a classroom does not mean they are going to be used in a pedagogical way (if used at all). Since computers and technological infrastructure are costly, it needs to go hand in hand with enhancement of quality teaching otherwise the quote from Conor Bolton becomes a reality.

\[
\text{Poor teaching + expensive technology} = \text{Expensive poor teaching}
\]

**Usage as a factor.** Improper use or lack of it by teachers due to human factors pose a big challenge to ICT integration in the pedagogical teaching of Biology. Teacher’s poor perception (Gakuu, 2006), lack of preparation (Zhiling & Hambing, 2001), low self efficiency (Bandura, 1986), un-established cultural factors (Martinez, 1999) together with lack of interest (Newton 2003), poor adaptability (Becta 2004) and poor attitude (Galanouli and MeNaair 2001) are a challenge to ICT integration. The transition from a sequential learning process where everything was foreseen, to a learning process where learners have to resolve problems does not happen without clashes. In all these endeavors to embrace technology under behavioral paradigm, attitudes are not easy to modify. Newton (2003) observed that while innovators and early adopters embraced ICT enthusiastically majority faculty members seem still disengaged and uninterested in learning. In addition some digital contests are designed in some complex manner that navigation to various sections of the same content is difficult. According to ministry of Education handbook (2012) a complex digital content has been a source of frustration to most teachers in ICT integration.

Teachers who have embraced technology must not just use technology for technology’s sake but must determine when it is necessary to use it otherwise they will be guilty of its improper use. Wellington (2000) aptly argues that teachers need to be able to judge when the use of ICT is effective and beneficial and when its use is ineffective or inappropriate. When successfully used in a proper context its benefit is intangible. Consider Wardsworth’s quote:

\[
\begin{align*}
\text{When I hear and I forget} \\
\text{When I see and I remember and} \\
\text{When I do and I understand} \\
\end{align*}
\]

(Wadsworth, 1978:161)

**ICT support structures.** Institutional and technical support is vital for implementation of ICT integration programs in schools. Many schools in Kenya lack computers and ICT infrastructure (Murithi 2005). Where a few computers exist the emphasis is on computer literacy and not ICT integration. According to the 1997 report by National Council for Accreditation of Teachers Education (NCATE) lack of technical support is one of the barriers that results in computers being under utilized in classes. Lai and Pratt (2006) concur and say that one needs ICT related support in the use or introduction of ICT into curriculum and teaching methods. Furthermore power blackouts are common phenomenon in most parts of Kenya. Whenever it happens electronic gadgets cannot be used thus interrupting either preparation or ICT integration. This is because many schools have not invested in alternative sources of power such as solar and diesel generators to mitigate the effect of un-reliable power. Some gadgets become defective after power fluctuations rendering them unusable. Technicians are hard to come by in case of minor malfunctions.
Other social factors. ICT integration is a new phenomenon and has not been part of the Kenyan Instructional culture. This 21st century innovation instructional method is now being Inco-operated in the education system. Martinez (1999) argues that one of the major challenge facing developing countries is how to make technology an essential part of the culture of the people. Harpes (1987) contends that cultural factors play an important role in creating a negative perception towards computers.

**Objective 4:** Overcoming challenges of ICT integration. Students and teachers mentioned various challenges that face ICT integration ranging from power interruptions to purchase of ICT tools

<table>
<thead>
<tr>
<th>Respondents</th>
<th>Talk to KPL to stop power interruptions</th>
<th>Buying generator/alternative power source</th>
<th>Recruiting ICT Teacher</th>
<th>Making computer compulsory</th>
<th>Recruiting technician</th>
<th>Buy computer accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>13</td>
<td>27</td>
<td>31</td>
<td>4</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>%</td>
<td>13</td>
<td>27</td>
<td>31</td>
<td>4</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Teachers</td>
<td>----</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>--</td>
<td>1</td>
</tr>
<tr>
<td>%</td>
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<td>40</td>
<td>20</td>
<td>20</td>
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<td>HOD</td>
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<td>%</td>
<td>-</td>
<td>--</td>
<td>20</td>
<td>---</td>
<td>-</td>
<td>80</td>
</tr>
</tbody>
</table>

The major remedy to the serious problem of power interruption is getting alternative power source. This problem of inconsistent power supply is even greater than that of lack of power. This means that the problem of connectivity is slowly being a thing of the past. Other major problems are lack of qualified teachers and technicians and costs of ICT tools.

The Kenya government through Session paper number 1 of 2005 and Kenya Education Support Sector Program (KESSP) paper outlined among other measures- facilitation of public private partnership to mobilize resource to revamp ICT infrastructure to support e-learning initiative. The government also offered to create cluster centers in primary school where some computers will be based for training teachers. Some chosen secondary schools were likewise staffed with computers for training to reduce costs involved in computer-assisted learning. To improve use of ICT, training of science teachers through CEMASTEA and SMASSE- INSET in the counties is continuously being undertaken. Apart from county training, pioneer trainers (champions) have been undergoing training so as to train other teachers in an effort to
improve their ICT skills. Steketee (2005) informs of preparation of teachers for ICT integration around the world as being approached in four ways:

1. ICT skill development approaches which according to Gill and Dalgarno (2008) comprises the addition of one or more ICT subjects within the preparatory course.
2. ICT pedagogy approach whose objective is to show course participants how ICT can be integrated as teaching and learning tool across the curriculum.
3. Subject specific approach that focuses on knowledge learning technologies that offer affordance to particular content area best explained by Mishra and Kohles (2006) as technological content knowledge.
4. Practice driven approach that includes preparing teachers to design and develop implementable ICT facilitated classroom programs and products. Concerning support structures the Kenya government through Economic stimulus program is striving to develop ICT infrastructure and through national ICT innovation and integration centre push for development and availability of computers.

Conclusion

Majority of teachers are ICT literate but require changing their attitude against computer use. Integration of computers in T/L can become universal if all stakeholders play their role and teachers are motivated to use them. The gains in using ICT are unprecedented. Performances in Biology and other subjects are likely to go up if integration of ICT is perfected.

Recommendations

1. Teachers should be allocated fewer teaching loads to enable them plan and execute ICT integration.
2. More teachers must be recruited to ease their loads and give them more time to incorporate technology into their teaching
3. More computers must be purchased to reduce Learner-Computer ratio
4. More technicians and teachers of computer must be recruited to fill in the technology gap
5. Computer rooms and other facilities must be put in place.
6. Teachers attitudes must changed through INSETS so that they can love to embrace ICT

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