

Availability of Information and Communication Technology Resources in Teaching and Learning of Biology by Secondary Schools in Uasin Gishu County, Kenya

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Abstract: *Information and communication technology (ICT) has become vogue in curriculum implementation in schools in most developing countries, Kenya included. Its proper usage can motivate students and enhance teaching and learning. This paper is premised on a study whose aim was to assess integration of information and communication technology in teaching and learning Biology in secondary schools in Uasin Gishu County in Kenya. In this paper, the author specifically assesses the availability of information and communication technology resources in teaching and learning of Biology in schools in the area. A descriptive survey research design was used in the study. The target population was 123 secondary schools. The study used stratifying sampling to select a sample of 114 teachers. Structured questionnaire and interview schedule were used to collect data. Descriptive statistics (frequencies, percentage, mean and standard deviation) were used to analyse data. The study findings indicated that the schools lacked some of the important information and communication technology resources for teaching and learning of Biology. The study recommends that the government should provide more funds for ICT materials in secondary schools.*

Keywords: Availability, Information, Communication Technology Resources, Teaching, Learning, Biology, Secondary Schools, Uasin Gishu County, Kenya

1. Introduction

The uses of ICT in schools are so diverse that it is almost impossible to list all possible applications. Taylor [1] identifies three roles of computers in a classroom: as tutor, tool and tutee. Introduction of ICT in Biology lessons can raise not only the level of knowledge but also improve students' attitudes towards Biology [2, 3]. Biology (science) teachers additionally have to distinguish between two groups of applications. In the first group are generic applications used in all subjects, like word-processing, searching for information, communication using e-mails, and multimedia presentations. In this case, if a science teacher does not use ICT in a classroom, damage to the students is limited because they can acquire the missing skills with their work in other subjects or at home [4].

In the second group are applications adapted or developed to be used in science teaching [5], like imaging systems in microscopy [6], virtual dissections [7], simulations [8], virtual laboratory [9], and real laboratory exercises with data acquisition systems [10]. The most important difference among these two groups of applications is that if a science teacher does not use such applications in teaching students, in most cases, they would not be able to compensate loss with work in other subjects or at home.

Tella, Tella, Toyobo, Adika and Adeyinka [11] have examined Nigerian secondary school teachers using ICTs and implications for further development of ICT used in schools using a census of 700 teachers. Their findings showed that most teachers perceived ICT as very useful and as making teaching and learning easier. The authors recommend that professional development policies should

support ICT-related teaching models, in particular those that encourage both students and teachers to play an active role in teaching activities. Additionally, emphasis should be placed on the pedagogy underlying the use of ICTs for teaching and learning.

Research and active development projects such as those run by EdQual, a Research Consortium of educational institutions in the UK and Africa (Ghana, Rwanda, South Africa and Tanzania) on Educational Quality typically indicate two main reasons why teachers use ICT. Firstly, they feel that their own use of computers benefits their learners, and secondly, teachers feel learners benefit from using computers themselves. Teachers see ICT as kindling students' interest and learning in the subject. ICT promotes a positive attitude towards information technology as an essential part of a lifelong interest in learning. Teachers also perceive the use of ICT as enhancing recall of previous learning, providing new stimuli, activating the learner's response, and providing systematic and steady feedback. It is further perceived as sequencing learning appropriately, and providing access to a rich source of information.

For example, Tella *et al.* [11] have found that computer use by teachers is driven by intentions to use it, and that perceived usefulness is also strongly linked to those intentions. The implication is that teachers are inclined to use technology if they perceive it to be useful. Furthermore, ICT needs to be linked to specific needs of learners, desisting from the one size fits all approach [12]. It is most effectively used as a learner-centred tool, instead of within a more traditional pedagogy. The real challenge for educationists is, therefore, how to harness the potential of ICT to complement the role of a teacher in the teaching and

learning process. There is an understandable apprehension, even fear, as to the role of a teacher in an ICT-equipped classroom [13]. Teachers who lack the chance to develop professionally in the use of modern ICT feel under threat. The relevance of a teacher in the 21st Century is determined by their willingness to develop in this way.

Globalization and the knowledge-based economy are leaving no choices for education systems worldwide but to adopt ICT and weave it into their educational milieus, and the Jordanian education system is no exception. The system has adopted several ICT-related education initiatives aiming to reform the system towards the knowledge-based economy.

In recent years, ICT-related initiatives are adopted and implemented by education systems with greater appreciation of their complexity. The major complexity with ICT integration into education systems is the many factors involved with it including those associated with the human side of the integration (e.g. teachers, on-going support, trainers, and headmasters) and the technological side of it (e.g. access to computers, technical support, and e-materials).

During the early attempts of integrating computers into education systems, the technology itself was overemphasized at the cost of the human side. These attempts were based on the assumption that technology can revolutionize education and, therefore, resources and efforts were diverted to providing schools with computers and other technologies. During that stage, technology was conceived as an end in itself, which resulted in computers being distributed to schools with little thought given to their best use [14]. However, the early attempts were doomed to fail as it became clear that technology could not improve educational practices and outcomes by itself. Therefore, focus was shifted towards other supporting factors to the successful integration of ICT across education systems.

The failure of the early attempts to revolutionize education through the infusion of computers shifted the attention considerably to teachers. Accordingly, teacher-related issues are discussed as integral components to any successful educational intervention and therefore have gained extensive research and debate [15]. For instance, Veen [16] asserts that teachers' beliefs about content and the pedagogy, along with their overall competence, far outweigh any other factor in respect of their adoption of ICT, including technical support provided by schools, and principals' support of ICT integration. Other studies have confirmed that teacher factors such as competence, attitude and time, are of a greater significance than factors associated with hardware [17]. Hence, preparing teachers to utilize ICT across the curriculum is paramount to any successful ICT-related initiative.

Teacher training courses, both pre and in-service, can help teachers who are tentative to move faster and adopt technology while they show the more enthusiastic teachers new ways in implementing ICT into their profession.

According to Fullan [18], innovation is not always synonymous with change and reform, as it refers to specific curricular change. Innovations can range from single subject changes, for example, a new reading programme, to more comprehensive changes, such as an integrated approach to teaching children of a certain age level. This implies that innovation has unique qualities such as novelty or deliberateness. In a similar way, Halpin, Dickson, Power, Whitty and Gewirtz [19] posit that curriculum innovation refers to initiatives that are perceived to be new by those who introduce and experience them.

Fullan [18] defines curriculum change as any alteration in the aspects of a curriculum such as philosophy, values, objectives, organizational structures, materials, teaching strategies, student experiences, assessment and learning outcomes. The concept "reform" also relates to a particular change, but it is usually concerned with more comprehensive and fundamental curriculum innovations. A reform involves the restructuring of the school system, wholesale revision of the curriculum and the like. It is based on major values changes or redirections and is often initiated in the political system.

To achieve Vision 2030, the Kenya Government had an ambitious plan to give laptops to school children which was however opposed by parents and various stakeholders who said that the money for the computers should instead go toward raising teachers' salaries and feeding children. The idea for ICT for all primary school learners will be good since it has worked in Zimbabwe, South Africa, New Zealand among other countries. Despite the rosy picture painted above, Kenya lacks trained teachers in ICT especially at the primary school level, which the laptop program targets. Providing the gadgets might be the easier part, but getting a Class One child to use them for educational gains must go beyond political rhetoric. The Kenya Institute of Curriculum Development (KICD), formerly the Kenya Institute of Education (KIE), which is mandated to develop curriculum under the Kenya Institute of Curriculum Development Act 2013, has already developed digital content in anticipation of the laptop rollout [20].

Muriira [20] recommends that for provision of laptops to work in Kenya, each primary school should have Wi-Fi connection that allows students to complete their tasks. The Operating Systems should be installed at no cost to the school, through agreements with Internet providers and/or mobile operators and the vendor providing the laptops. The ICT trained teachers to also work with students to bolster computer knowledge, because with the use of ICT also strengthens the teacher's repertoire of skills and opens up a wider array of learning resources for students to access. Therefore, the rich, interactive capability of ICT-mediated learning resources also motivates and engages weaker students, and allows them to learn at an appropriate pace, and teachers to adopt scaffolding strategies in all ICT-mediated lessons to engage students in higher-order thinking activities [21]. Thus teachers and students have to experience the benefits of the laptops and the new ways of learning and working.

Behind the push for the laptop project in teaching and learning is a policy and legislative framework that aims at reforming education and training sectors in Kenya in line with the Constitution and Vision 2030 [22]. Sessional Paper No. 14, 2012, provides a framework on Education and Training and it notes in part: "ICT is a major vehicle for teaching and learning from the earliest years". In that policy ICT facilitates the opportunity for more student-centred teaching, more self-learning and more peer teaching. It also provides greater opportunity for teacher-to-teacher, and student-to-student communication and collaboration and access to the worldwide web and the learning resources contained thereon. The introduction of laptops in teaching and learning in class one is well grounded in educational psychology [22].

1.1. Availability of Information and Communication Technology Used in Teaching Biology

With the increased use of ICT as a means of instruction, 'the decreased importance of physical distance means that the best (and the worst educational and corporate institutions) of any country can decide to open a branch anywhere in the world or to reach out across borders using the internet or satellite communication links, effectively competing with any national university on its own territory'.

The Internet has granted access to a wealth of information previously unavailable to people. The danger for all students is that information is presented as fact without verification or references. It is therefore imperative that students are taught how to search effectively and to judge the credibility of what they find both essential skills for scientifically literate citizens. The Internet can allow students to research background information related to practical work being conducted, when asked to do so by a teacher. It allows students to choose the research areas they want to study, the depth of their research and, given Internet access at home, the time frame for carrying it out. In Biology, internet is used to conduct background research before the work is carried out.

Data logging is one of the main applications of ICT used to support practical work. Data logging refers to the process of collecting data using a computer, but is also linked to how the data are displayed and analyzed and is one of the main applications of ICT used to support practical work [23]. It has been suggested that data logging has the potential to enhance students' thinking about and understanding of science (ibid), as it removes the need for low-level data-collection skills and allows students more time to focus on the analysis of the data and application of theory. It removes the need to manipulate intricate equipment, as long as there is support on hand to help set up the data loggers and computers. It also produces a clear output almost instantaneously, removing the need to draw graphs by hand or spend time inputting the data manually. It can also help those with visual impairment, who may struggle to collect data from traditional instruments such as thermometers, allowing them to create clear electronic output formatted to their own preference. Nonetheless, data logging is not a miracle solution which enables students with disabilities to conduct every experiment. There are, for example, still

accessibility issues for many students when it comes to conducting fieldwork. At present there are only a limited number of sensors available, although the range is continuing to grow.

It is also important that the teacher still takes an active role in supporting learning, rather than letting the computer show the data and leaving the students to analyze the data on their own [23]. This emphasizes the importance of scaffolding, teacher support and dialogue to help students construct their understanding [24]. It has been argued by Rogers and Finlayson [25] and Rogers [23], however, that there is a clear time and place for data logging, and that it should not replace all traditional methods at all times because practical skills, such as reading a thermometer, still form an important part of science. It should only be used when the lesson objectives and learning outcomes focus on analysis and theory, rather than on the 'hands-on' aspects of learning science. In Biology, Data-logging can be used to collect information which removes the difficulties associated with papers getting lost, being blown away or destroyed by rain. It can also be used effectively to collect data over an extended period of time – e.g. changes in the oxygen concentration in pond water over 24 hours.

Control and monitoring – remote experimentation: Where gaining access to a laboratory is problematic, remote experimentation can be used. Examples of this are the PEARL project [26] developed for the Open University, and the use of radio telescopes. Remote experimentation has a number of advantages over simulations (to be discussed later) in that it allows manipulation of the equipment and gives the students the opportunity to make mistakes and collect anomalous data (ibid.). This is an important part of learning, as recognizing that the data are not what you were expecting, and then trying to explain why, involves exploring a theory to a much deeper level of understanding – evaluating and synthesizing it, rather than just recalling the textbook explanation.

A strong advantage of working remotely is the chance to work at your own pace, and thus take time to reflect on the information presented. If technology to allow communication was linked with students undertaking remote experimentation, virtual field trips or tours of museums, an extremely powerful tool would be created, allowing students access to both the methodology of the work and the theoretical discussion behind it. They would then gain crucial experience of being active participants in their learning [27] and interacting with their peers in Biology.

Models and Modelling – Simulations: There is a wide range of commercially available simulations. These allow students to carry out virtual experiments, or use visual aids to help explain phenomena. The most common and effective use of simulations is to demonstrate practical's that may be too dangerous to conduct in the classroom or unrealistic because of the time frame or environment needed (e.g. showing the effect of introducing a new predator into a food chain). Simulations can be very powerful tools, but often the learning opportunities and assessment inherent in the software do not extend beyond checking recall of facts [28];

they provide no way for students to get hands-on experience of the practical work or to manipulate equipment, which is an important aspect of learning (ibid).

As most simulations are relatively basic in their programming, the students will not collect anomalous results. Although, initially, this may appear to be a good thing, it does not challenge students to think and explain their results, and thus it does not challenge their existing conceptions of science or force them to assess the accuracy of their theories. More advanced simulations can serve as 'intellectual partners' to the students and support their higher-order thinking skills; however, these programs are often expensive, and are unrealistic options for most schools. In Biology, simulations and models can be used, by those unable to gain access to fieldwork sites, to investigate phenomena or to collect additional data.

Exchanging and Sharing Information: 'Enabling' or 'assistive' technologies are one obvious area in which ICT can support students with physical or sensory disabilities [26]. These can be divided into technology which supports the input of information into a computer, and that which helps students access the output from the computer. Input methods include alternative keyboards, speech recognition software and substitutes for a mouse. Output methods include screen-readers or a Braille display, magnification software, transcripts of speech, or even just the ability to alter the character size, style and colour combinations on standard programmes. All of these are for short-term use; those who would need to use these on a regular basis are advised to invest in higher-specification programmes.

A major drawback with assistive technologies, particularly software, is that the software may not be compatible with certain systems, or may compete for memory, slowing down the whole process. In both these cases the assistive technologies can actually create more barriers to learning than there were at the start. Cooper [26] makes a clear case for institutions to set 'accessibility criteria' for selecting software packages, and to train support staff to solve technical problems in order to avoid ongoing difficulties.

Virtual learning environments, discussed by Cooper (ibid), allow for activity and progress to be tracked, provide access to learning support material and services and present curriculum material. Most importantly, they can support students in communicating with teachers and peers. This aspect means that virtual learning environments have the potential to enable students with physical or sensory disabilities to become active participants in the learning community, rather than just passive observers, thus reflecting the constructivist learning theories [27] which seem to underpin their design. Among the main advantages of ICT use by disabled students is the ability to alter the time in which the work must be completed. As documents can be saved, accessed via the Internet, or emailed to another person, it opens up the opportunity for work to be completed at another time and place.

In almost all practical work, data of some sort are collected. Software packages such as Excel enable students to use spreadsheets to analyze data and create a wide variety of

graphs to display information visually, often aiding analysis. This can reduce the time needed for the mechanics of drawing graphs. This ability to save time is especially important for those students whose physical restrictions make it very difficult for them to draw graphs. It also makes it possible for those who could not physically produce a graph via traditional methods to produce graphs for themselves. In these cases, being able to generate graphs on the computer, with or without the aid of other assistive technologies, is invaluable. It allows the students to 'see' the data in order to begin to explain the results using their scientific knowledge. However, it is still important that students develop understanding of the process, and where physically possible they should practice these skills. For example, in post-16 Biology students are required to conduct statistical tests on data they have collected. They could put the data into a software programme, such as Excel or SPSS for Windows, but they will not understand the logic of the test, and so will not be equipped with the knowledge to assess the reliability of the result.

Spreadsheets can be used to store, process and display data, allowing time to be spent analyzing rather than hand-drawing graphs. Digital Photographs can be taken to give a permanent record of the site, which can then be shared easily with other members of the group. Word-Processing or Speech-Recognition software could allow students with physical disabilities to produce a report more easily.

In particular, Becta [29] points out, the use of interactive multimedia software, for example, motivates students and leads to improved performance. Barak [30] says that the use of ICTs in education promotes deep learning and allows schools to respond better to the varying needs of the students. According to Menjo [31], the dilemma that arises in providing educational technology stems from a lack of financial resources, lack of knowledge and skills and a limited distributive capacity. In Kenya, most teachers, instructors and students cite insufficient access to computers as the main obstacle in ICT for education programmes. This is particularly relevant for educational institutions located in the rural areas where the school or training institution is often the only access point for ICT resources for example computers, printer, modems, laptops, internet, router, phones, among others.

1.2. Problem Statement

A review of studies on the use of technology in education has consistently found that students in technology-rich environments experience positive effects on performance in all subject areas. Despite the many advantages associated with the use of ICTs that have been documented in past literature and the numerous government efforts to investment in training and resources to integrate the use of ICT in its operations, the rate at which ICTs are used in the Kenyan classrooms is still far below expectation. For the realization of the Kenya Vision 2030, secondary school teachers need to use adequate computers in classroom teaching. In addition, the demand for ICT learning has been tremendous and the number of teachers who are trained to teach ICT cannot meet the demand. This failure to use ICT is itself a result of the prevailing digital and knowledge

divides, and their causes are deeply embedded in the learning and performance of Biology. Therefore, there is need to energize action to bring technology into the classroom for improved Biology teaching, learning and performance. As such, the study sought to investigate integration of information and communication technology in the teaching and learning of Biology in secondary schools in Uasin Gishu County.

1.3. Limitations of the Study

The research into the integration of ICT in teaching Biology was relatively new and hence little information on the subject was accessed. In addition, teachers and students who are steeped in the traditional method of teaching Biology and are still groping in the dark were reluctant to volunteer information. However, the author overcame this obstacle by explaining to the teachers that the outcome of the study would result in success of the teaching and learning of Biology in the District. The study was only limited to 123 schools using ICT in teaching and learning Biology in Uasin Gishu County, where descriptive survey research design was used.

2. Materials and Methods

The research used a descriptive survey design. It was conducted in Uasin Gishu County which is a cosmopolitan area. The target population included all trained Biology teachers and principals/head teachers in all 123 secondary schools in Uasin Gishu County. The study sampled 30% schools from a population of 123 giving 38 schools. From each of the secondary schools, 3 Biology teachers were selected randomly to participate in the study. The Biology teachers were randomly selected because of their knowledge in Biology and use of laboratory as well as their contact with the modern ICT while the Heads of Departments (HoDs) were selected purposively. Therefore, the total number of teachers selected from 38 schools was 114. Head teachers of every school sampled were selected purposively to participate in the study, making a sample of 38. The total sample size of the study was therefore 152 respondents.

The instruments used to collect data for this the study were self-administered questionnaires, observation and interview schedules. DATA was analyzed descriptively. Data analysis was facilitated by use of Statistical Package for Social Science (SPSS) computer program. Descriptive statistics were employed in analyzing qualitative data where frequencies and proportions were used in interpreting the respondents' perceptions of issues raised in the questionnaires so as to answer the research questions.

3. Results

3.1. Availability of ICT Resources in Teaching/Learning Biology

Technology is a defining force in contemporary living and it is relevant in the teaching and learning of Biology. The study findings reveal the state of availability of the various ICT resources in the secondary schools in Uasin Gishu County. From the findings, it was shown that calculators are

the most available (80%) for teaching/learning of Biology in secondary schools. In addition, Software such as Word, Access, Excel (71%), digital cameras (76%), laptops/net books/tablets/ipads (74%), satellites disks/decoders (84%), UPS power supply and networking cables (71%) were indicated as not available for teaching/learning of Biology

Teachers were not sure if other ICT resources, e.g. Modems/routers, Monitors, scanners, television), video cassettes players and recorders, networking cables, scanners, television speakers and headphones, were available for use in the teaching/learning of Biology. This implies that teachers were not conversant with the basic accessories used in the ICT teaching/learning of Biology.

3.2. Use of Mobile phones

In regard to the use of mobile phones to access Biology information, majority of teachers said they frequently used them (63.6%) while a few teachers rarely used (36.4%) them. The high percentage (63.6%) of use of mobile phones to access information was attributed to frequent flexibility and ease of use of the mobile technology to access Biology information while the small percentage (36.4%) usage of mobile phones was attributed to no frequent flexibility and easy access to Biology information.

3.3. Functions of Mobile Phones in Teaching/Learning in Biology

Table 1 presents the responses on the functions of mobile phones to a teacher when in classroom. The author found it necessary to assess those functions because phones are easily accessible and affordable and some of them have the capacity to perform functions as do computers.

Table 1: Function of Mobile Phones in Teaching/Learning Biology

	<i>Frequency</i>	<i>Percent</i>
Internet for searching Biology contents	61	55.5
Networking to share the Biology information	12	10.9
Make Call to schedule for Biology class/time tabling for class activities	20	18.2
Entertainment to relax the minds after Biology lesson	11	10

The research findings shown in Table 1 indicate that teachers who personally used mobile phones used it to access the internet, 61(55.5%), for networking, 12(10.9%), to make calls 20(18.2%), and for entertainment, 11(10%).

4. Discussions

The study findings showed that there is a positive relationship between availability of information and communication technology resources and teaching/learning of Biology. Information and communication technology can enable students to access background information that is related to practical work before the work is carried out particularly in Biology. The findings, therefore, concur with the views of Rogers [23] on the use of ICT in practical work that through data logging one is able to collect data and analyze it using the computer hence enhancing students' thinking on and understanding of science. This gives

students more time to focus on the analysis of their data and application thus implying a positive effect on learning/teaching of Biology (ibid.).

ICTs enable students to evaluate and synthesize useful information from raw data rather than just recalling the textbook explanation. Moreover, the use of control and monitoring-remote experimentation has a positive effect on the learning/teaching of Biology. This is because remote experimentation allows students to access both the methodology of their work and the theoretical part of it. In this way, students gain the experience or use visual aids to help explain phenomena. Therefore, Biology students who are unable to gain access to field work sites can use simulations instead. The use of ICT is important for students with physical restrictions since they can use software packages such as Excel, for instance spreadsheets, to analyze data and create a wide variety of graphs to display information visually hence aiding analysis and saves on time for them since it is difficult for them to draw graphs. Therefore, students with physical or sensory disabilities are able to become active participants in the learning process [27].

The study findings also showed that ICTs in secondary schools in Uasin Gishu County have demonstrated the potential to increase the options, access, participation and achievement for all students. As a result, information and communication technology has become a powerful means of communication and technology. Particularly, learning has been made easier and students have become less dependent on teachers due to the availability of ICT resources. Further, the use of the internet was evident in the teaching and learning of Biology. In reference to Biology, the internet is used to conduct background research before work is carried out. Additionally, the internet is also used to enhance students' thinking about and understanding of science [23]. From the study findings, it is clear that the use of ICT is of great benefit to learning/teaching Biology.

5. Conclusions and Recommendations

The study affirms that the availability of Information and Communication Technology resources has a significant effect on the teaching/learning of Biology. From the study findings, it is clear that technology allows learning to take place anywhere at anytime; not just in one particular place. ICTs also provide depth of learning through interactive simulations and illustrations. They also foster collaboration; students can work collaboratively on projects with others who may not be physically close through the use of computer tools such as the electronic mail.

Based on findings of the study, ICT materials should be made available so as to enhance the use of ICT in learning/teaching Biology. Since ICT availability is one of the most important obstacles to technology adoption and integration in learning, secondary schools should make an effort towards increasing the availability and accessibility to ICT resources. Furthermore, ICT equipment such as smart boards should be availed so as to achieve qualitative improvements in learning.

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