International Education Studies and Sustainability
ISSN 2766-4554 (Print) ISSN 2766-4562 (Online)
Vol. 1, No. 1, 2021
www.scholink.org/ojs/index.phi/iess

Original Paper

Enhancing Biology Achievement of Secondary School Learners Using Experiential Computer Assisted Instruction

Peter K. Ronoh[1] Fred N. Keraro[1*] & Samuel W. Wachanga[1]

[1] Department of Curriculum, Instructions and Educational Management, Egerton University, P.O. Box 536-20115, Egerton, Kenya

[*] Fred N. Keraro, Department of Curriculum, Instructions and Educational Management, Egerton University, P.O. Box 536-20115, Egerton, Kenya

Received: November 17, 2020 Accepted: November 23, 2020 Online Published: February 27, 2021
doi:10.22158/iess.v1n1p59 URL: http://dx.doi.org/10.22158/iess.v1n1p59

Abstract

This paper reports a study that investigated effects of Experiential Computer Assisted Learning (ECAI) on learners' achievement in Biology in Kenya. Solomon's Non-Equivalent group four research design was used. Four schools were purposively sampled. The schools were randomly assigned to four groups, two experimental and two control groups. All the learners covered same content. Teachers of the experimental groups used ECAI while teachers of control groups used regular approaches. The study focused on the topic Genetics and involved a sample of 163 Form Four learners. Biology Achievement Test (BAT) was used to collect data. The instrument was validated by five experts in Educational Research. Reliability of BAT was estimated using Cronbach's alpha coefficient. A co-efficient of 0.719 was obtained. The Constructivist and Experiential learning theories guided the study. Data collected were analyzed using ANOVA, t-test and ANCOVA. Hypotheses were tested at an alpha level of 0.05. The findings indicate that learners taught using ECAI had significantly higher scores than those in control groups. It is recommended that the Kenya Institute of Curriculum Development (KICD) incorporates ECAI in the teaching of school Biology to enhance learning. Science teacher education programmes should also incorporate ECAI to enhance its use in schools.

Keywords

experiential computer assisted instruction, school biology and biology Achievement

1. Introduction

Science is generally regarded as having great significance for the economic well-being of nations (Fraser & Walberg, 1995). Therefore, scientific knowledge is a necessity in all countries and for all people Worldwide to overcome the various challenges faced. Such challenges include the emergence of new drug-resistant pathogens and pandemics, the consequences of genetic experiments and innovations, ecological impact of modern technology, and global warming (Alsop & Hicks, 2001). Hence there are several changes taking place in industry, agriculture and medicine that science education need to respond to. Science as a tool for development should play an important role in bringing about these improvements by advancing technological development, fostering the growth of national wealth, enhancing human health and industrialization (Validya, 2003).

For the Kenya Government to meet the Sustainable Development Goals (SDGs) by the year 2030, it should improve science education. The two SDGs that focus on education are: first, to ensure inclusive and quality education for all and promote lifelong learning, secondly is to achieve gender equality and empower all women and girls. Biology being one of the science subjects offered in the secondary school cycle, should be improved to meet the prevailing challenges. Keraro, Wachanga, and Orora (2007) emphasize that Biological knowledge has a wide range of applications in most aspects of human life. It's applications in genetic engineering have led to the development of plant and animal species with high yields. This has made a considerable contribution in meeting the ever growing human population's demand for food requirements. Biological information has also been applied in areas of medicine such as organ transplant and management of a wide array of diseases. Biological knowledge is applied in industry such as the use of microorganisms in food processing. Other fields where Biological information has been applied include population control and environmental conservation (UNESCO, 1986).

Despite this importance of Biology, secondary school learners' achievement in Biology has remained low for several years. Various studies have revealed that learners' who have negative stereotype images of science in society are not likely to pursue science related courses and usually perform dismally in science subjects (Changeiywo, 2000). The concern is that achievement in Biology is poor.

This investigation was based on the topic genetics. The steady progress in genetic research, forensic science and the direct role that genetics plays in human health and reproduction make it a topic in secondary school Biology that every learner needs to understand. This includes the properties and functions of genetic materials, heredity and mutation laws and methods, genetic procedures and the related practical applications. All activities of life take place on the basis of the genetic background of the organisms. Many diseases and deficiencies are caused by abnormal changes in genetic material (Liang, 2004). Various studies have revealed that learners don't critically understand the genetics knowledge taught in the classroom and hence inability to apply genetic knowledge to their everyday lives (Lewis & Kattmann, 2004). The topic genetics is one of the poorly performed topics in KCSE Biology every year. The teaching of this topic, therefore, needs to be comprehensive with clear emphasis and illustrations of all the genetic processes and stages involved (KNEC, 2017).

An approach that can result in meaningful learning should encourage deep, critical thinking about the concept in question. In an era where a lot of information is readily available on several topics including genetics, it is prudent to search for approaches that enhance meaningful learning. In most cases learners often learn only passively through lectures, reading assignments or searching in the Internet. Development of critical thinking skills is necessary to ensure a level of literacy and the eventual ability to apply the knowledge. Providing learners a conducive environment to explore challenging areas in genetics through interactive approaches is one way of achieving this goal.

Since 2003, the Government of Kenya has implemented a revised curriculum in secondary schools, and has a revised examination format (KNEC, 2007). The first examinations in the revised curriculum were done in the year 2006. Notable changes in this curriculum include: Harmonization of the three science subjects that is Biology, Physics and Chemistry in terms of the number of papers, the format of the papers and the maximum marks allocated to each paper (KNEC, 2007). This format was intended to encourage learners' to take sciences (Orende & Chesos, 2005). Even with these changes, achievement in Biology is still low, probably because of the instructional methods applied by teachers. The instructional method that a teacher adopts influences learners' achievement (Mills, 1991).

Studies carried out have revealed that regular instructional approaches in Biology are less effective than interactive approaches (Caldwell, 2007). For instance, lecture based instructions are the less popular form of instruction encountered by learners (Sander, Coates, King, & Stevenson, 2000). Bligh (2000) concludes that lectures are useful for the dissemination of knowledge but do not encourage thinking or attitude adjustment, do not allow for acquiring behavioural skills or generate interest in the subject. To order to accommodate changing learner preferences such as lifelong learning, different learner and employer requirements, and current learning approaches, it is important to create new and different forms of teaching (Holley & Dobson, 2008).

Interactive approaches enhance mastery of content by actively engaging learners in the learning process and promoting a positive attitude towards the subject (Ministry of Education, 2001). This allows learners to practice the language and establish the beauty of learning materials (Ahmad & Aziz, 2009). According to Froyd (2007), some key features of interactive approaches are: collaborative learning, connecting new information to previous knowledge and critical thinking. Other features include: facilitating presentation of questions for small groups' work. It also includes the use of media and involvement of learners in field activities. Furthermore, teachers who use interactive approaches allow for varied learning styles among their learners and encourage active involvement of all learners, while helping them to improve on individual weaknesses (Curtin, 2005). This approach also encourages learners to ask questions, define problems and lead conversations. Besides, such methods connect learners' world with learning pursuits in the classroom (Bush, 2006).

In pursuit of achieving the goals of secondary school education and to improve on achievement, various interactive instructional approaches have been explored in Kenya. It has been demonstrated that cooperative concept mapping approach enhances learners' motivation in learning Biology (Keraro, Wachanga, & Orora, 2007). Keter and Wachanga (2013) observed that cooperative mastery learning enhanced learners' motivation in learning Chemistry. Wambugu and Changeiywo (2008) found that mastery learning enhanced learners' achievement in Physics. Mugiria, Wachanga, and Mbugua (2015) found that Advance organizer teaching approach enhanced learners' self-concept in Chemistry. It has also been demonstrated that use of advance organizers enhances learners' motivation in learning Biology (Shihusa & Keraro, 2009). Kinya and Wachanga (2015) also observed that experiential concept mapping teaching strategy enhanced student's motivation in chemistry.

Experiential learning is a method of teaching through which learners make sense out of direct experience. Dewey's (1938) learning by doing philosophy stresses the importance of active engagement in learning. From an experiential standpoint, learning is a mechanism in which the transforming experience generates knowledge (Kolb, 1984; Kaagan, 1999). Optimum learning occurs when learners associate previous experience with new ideas they encounter (Kolb, 1984).

Experiential learning utilizes experience in an exceedingly distinctive context to facilitate information acquisition and creation. Learners engaged in experiential learning are in direct contact with the topic being studied (Kolb, 1984). During experiential learning, learners are ready to ground their understandings and new discoveries in their own previous concrete experiences to construct ideas and relationships actively in their own minds. Kolb (1984) perceives experiential learning as a four stage cycle. These are concrete experience, reflective observation, abstract conceptualization and active experimentation. Learners begin with a concrete experience, where they actively participate in a new experience. This is followed by reflective observation, where learners watch around and take into account numerous experiences. Following this period of reflective observation, is abstract conceptualization. Learners weave their thoughts along to make theories and conclusions concerning an experience. Once developed, learners actively check their theories and conclusions to confirm whether they are correct or not (active experimentation) which successively, results in new experiences and renews the learning cycle (Barker, Jensen, & Kolb, 2002).

In this study each of these four components were incorporated as follows:

- To foster concrete experience, practical activities and supplemental computer simulations were employed.
- To foster reflective observation, questions, brainstorming activities and lesson tutorials were used.
- To foster abstract conceptualization, questions related to the experience were administered.
- To foster active experimentation, discussions and teacher clarification were employed.

Experiential learning strategies are notably helpful for ability development and as a result they provide learners with a chance to apply their skills and mirror on the experience (Feldon, 2007). Experiential learning has been applied in various fields (Kayes, 2002). A study by Adoye (2014) on the effects of experiential and observational learning techniques on secondary school Biology learners' attitude towards environmental education observed a significant effect on learners' attitude which in turn enhances achievement. Millenbah and MillsPaugh (2007) observed that using experiential learning in wildlife courses improves retention, problem solving and decision making. Furthermore, learner's bear in mind solely a fraction of what they hear but a majority of what they actively do (Borg & Stranahan, 2002). The necessary factor is personal involvement, whether or not it is talking concerning the subject with others, applying ideas to real world or teaching their peers. Learning is viewed as the product of practical, personal, thoughtful, lived experience. According to experiential learning, real learning happens once learners apply ideas by having to figure them out in different situations and experience the issues first hand. Experiential learning makes the student neutral in learning, and this improves the ability to integrate new concepts learned. However, this teaching strategy lacks a mechanism to concentrate on learner awareness in a learning context (McMullan & Cahoon, 1979; Miettinen, 2000), moreover certain concepts in the topic genetics lacks hands on activities. In this study an attempt was made to provide technical support using CAI, to facilitate experiential learning.

Computer Assisted Instruction (CAI) are instructional activities that use a computer as the primary teaching tool. Literature reveals that it is an effective approach in that it provides personalized instruction and learning happens at learners' own pace and time frame (Curtis & Howard, 1990). CAI enhances learning and improves retention rate, it motivates and develops a sense of efficacy (Cotton, 2001). It also allows a learner to interact with a computer (Chabay & Sherwood, 1992). Because of this, it is not possible for a learner to assume the role of a mere observer (Lockard & Abrams, 1987). A study by Ronoh, Wachanga, and Keraro, (2013) on the effects of computer based mastery learning on secondary school learners ' in achievement in Biology revealed that learners taught using computer based mastery learning out performed their counterparts taught using regular teaching methods. Wekesa, Kiboss, and Ndirangu (2006) in their study on Improving Learners' understanding and perception of cell theory in school Biology using a computer based instruction simulation program, observed that Computer Based Instruction improved learners' understanding and perception of cell theory in school Biology. Yusuf and Afolabi (2010) on their study on the effects of Computer Assisted Instruction (CAI) on Secondary School Learners' performance in Biology observed that CAI enhanced secondary school learners' achievement in Biology. Few studies have been reported on the topic genetics.

Various researchers have implemented computer-supported methods for integrating experiential learning events. For instance, simulation frameworks that have been integrated to allow learners to engage with real and dynamic phenomena. Lai, Yang, Chen, Ho and Chant (2007) in their study on the availability of mobile experiential learning technology found that mobile technologies are successful in enhancing information generation during experiential learning. A research of engineering learners using a computer simulation in combination with classroom instruction provided evidence that a significant increase in subject matter retention was made relative to learners using conventional methods of teaching alone (Firth, 1972). A report by Kenya National Examination Council suggested that effective integration of Information and Communication Technology (ICT) in the teaching of the topic genetics can enhance learners understanding of the genetic concepts, (KNEC, 2017). One way of integrating ICT is the use of Computer Simulations. Simulations are useful tools for teaching genetics, as they enable experiments and expertise to be applied to a particular context (Pal, Stubbs, & Lee 2005).

Furthermore, feedback delivery and the immersive design of simulations help to keep learners involved (Smith, 2001). Bringing simulations into the classroom in genetics offers learners the opportunity to find out about these genetic processes by observing them and focusing on the results of their actions. Furthermore, the simulation is seen by learners as an efficient teaching resource and the events are viewed as valid.

In this study Computer Assisted Instruction simulation was used to supplement experiential learning, simulations provide interractive learning experiences, through the supply of feedback or the opportunities for experimentation (Canhorto & Murphy, 2016). It is referred to as Experiential Computer Assisted Instruction (ECAI). It was used to teach the Biology topic on Genetics. In view of the fact that this hybrid approach took advantage of the benefits of CAI and experiential learning, it investigated its effectiveness in enhancing achievement in Biology.

1.2 Conceptual Framework

Figure 1 shows the conceptual framework which guided the investigation on the effects of using ECAI on learners' achievement in Biology.

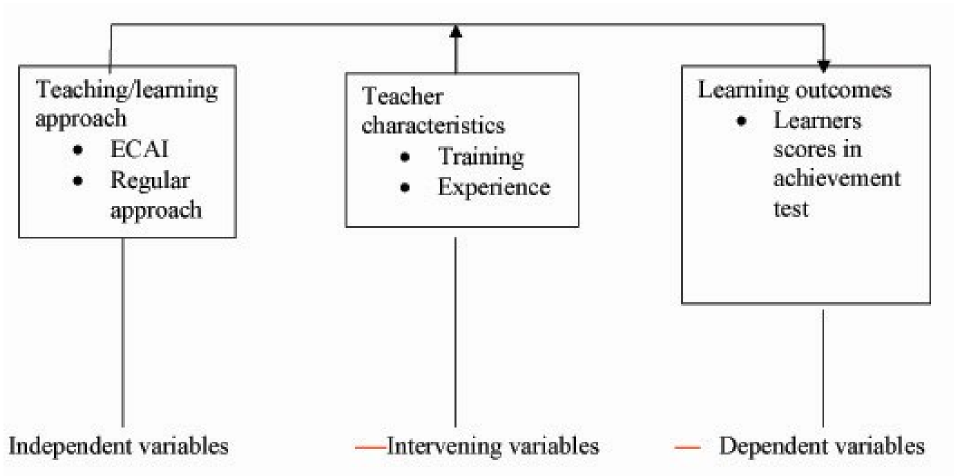

Figure 1. Conceptual Framework for Determining the Effects of Using ECAI on Learners' Achievement in Biology

The conceptual framework shows ECAI as an intervention in the teaching of the topic Genetics on learners' achievement. The dependent variables in this study were learner's scores in Biology achievement test. The independent variables were ECAI and Regular teaching methods. The intervening variables are teacher's training, experience and gender. The training of teachers was regulated through the use of qualified Biology teachers. The experience of teachers was controlled by the use of teachers who have been teaching Biology at high school level for a minimum of three years.

1.3 Objective of the Study

The specific objective of this study was to determine whether there is a difference in learners' achievement in Biology between learners exposed to ECAI and those exposed to regular teaching methods.

1.4 Hypothesis of the Study

There is no statistically significant difference in achievement in Biology between learners exposed to ECAI and those exposed to regular teaching methods.

2. Methodology

This study used the non-equivalent Solomon's Four Group Design. The design overcomes limitations in external validity found in other designs and also has better control by providing two control groups relative to other experimental designs (Borg & Gall, 2000). This design entails a random allocation to four sections of separate classes. The study adopted a quasi- experimental design, as the subjects are already constituted and school authorities don't allow reconstitution for research purposes (Borg & Gall, 2000). Figure 2 shows a Non equivalent Solomon's Four Group design.

Group I	O_1	X	O_2	Experimental group
Group II	O_3	-	O_4	Control group
Group III	-	X	O_5	Experimental group
Group IV	-	-	O_6	Control group

Key: Pre-tests: O_1 and O_3

Post- tests: O_2, O_4, O_5 and O_6

Treatment: X

Figure 2. Non-Equivalent Solomon's Four Group Design

2.1 Sampling Procedures and Sample Size

Schools which have computers and have had similar KCSE Biology mean scores in the years 2014-2018, were sampled for study. A total sample of 163 subjects were used. Purposive sampling was used to select four Sub County secondary schools which have computers. Four schools were chosen because each school formed a group in the Solomon Four- Group Design to minimize the interaction during the exercise. The selection of the schools to either experimental or control groups was done using simple random sampling. In experimental schools, all the streams were exposed to the treatment. Balloting was used to pick a stream for data analysis.

2.2 Instrumentation

The instruments used in this study are the Biology Achievement Test (BAT). These instruments were used to measure learners' achievement.

2.3 Biology Achievement Test (BAT)

BAT was constructed by the researcher and used to measure learners' achievement. The instrument comprised of a total of 17 items. All the 17 items in the instrument were drawn from the topic Genetics. The test items tested knowledge, comprehension, application, analysis, synthesis and evaluation. This same instrument served as a pre-test and post-test after reorganization of the items. This was done by changing the order of items in the test. This allowed for comparison between pre-test and post-test results. The test items had scores ranging from 1-6. A moderated marking scheme was used to mark the test. The minimum score in the BAT was zero and maximum score 70 marks.

2.4 Development of Instructional Materials

The researcher developed an instructional module for the learners and manual for teachers involved in the use of ECAI. The manual focused on objectives, content to be covered in the topic and teaching/learning activities. The manual was based on revised KIE (2002) Biology syllabus. Teachers of the experimental groups were trained by the researcher for one week on how to use ECAI. This was to enable them master the skills of using ECAI approach. The module consisted of experiential learning activity design and support system for experiential learning.

2.5 Data Collection Procedures

Permission was sought from the National Commission for Science, Technology and Innovation (NACOSTI) through the Director, Board of Post Graduate Studies of Egerton University to conduct the study. The researcher visited the selected schools before hand for acquaintance with targeted respondents (learners). This exercise assisted the researcher in familiarizing himself with teachers of the experimental and control groups explaining the essence of the study and booking appointments for the data collection. After familiarization, data was then collected from the respondents. This was done by administering a pre-test BAT and SDQ to groups I and group II. Intervention period was six weeks. After the end of intervention period a post-test was administered to all the four groups. The class subject teachers in each school administered the research instruments. The researcher scored the BAT and SDQ. Quantitative data from the scores was generated for analysis.

3. Results

Quantitative data was generated by administration of BAT to control and experimental groups. Data obtained was then analysed using inferential statistics, t- test, ANOVA and ANCOVA. The t-test was used to test the difference between pre-test mean scores. ANOVA was used to identify the difference in post-test mean scores between experimental groups (I and III) and control groups (II and IV). ANCOVA was used to cater for initial differences in experimental and control groups.

To establish whether the experimental and the control groups were similar at the beginning of the study the pre-test scores of BAT were analysed using t-test based on equality of variances. The results are shown in Table 1.

Table 1. Independent Sample T-test of Pre-test Scores on BAT Based on Froups E_1 and C_1

Scale	Group	N	Mean	*SD*	*df*	*t*-value	*p*-value
BAT (maximum = 5)	I	43	20.16	5.79	80	4.350	0.000*
	II	39	14.38	6.24			

* Significant at .05 level.

Table 1 shows that the pre-test mean scores in BAT for experimental group I (M = 20.16, SD = 5.79) while for control group II was (M = 14.38, SD = 6.24), t (80) = 4.350, p<0.05. This showed that there was a significant difference in achievement between the experimental group and control group in favour of the experimental group. This implies that the two groups were not similar at the point of entry. ANCOVA procedure was, therefore, used to adjust for this difference. Table 2 shows the ANCOVA results.

Table 2. ANCOVA pre-test BAT Mean Scores Using KCPE Scores as Covariate

Source	Sum of squares	*Df*	Mean square	*F*	*p*-value
Learning approach	732.645	1	732.645	20.860	0.000*
Error	2704.396	77	35.122		

Table 2 reveals that the difference between the two groups, the experimental group I and control group II is statistically significant, F (1, 77) = 20.860, p<0.05. This, therefore, implies that the covariate used did not adjust the means.

There is a possibility, therefore, that as much as the two groups used were in the same category of schools with similar entry behaviour, there are other external factors which influenced their difference in achievement. First is the nature of school environment- The experimental group I (E_1) had better facilities in terms of classrooms, a more equipped library and laboratories. This led to enhanced achievement. Secondly is the subject teachers- It was realised that teachers for the streams selected for study in the experimental group were more experienced than teachers in the control group II (C_1) had higher achievement. Third in sampling, overall school means were used to sample schools for study. Learners' Biology achievement in a school could be low or high, and in this case it was realised that group I ($_{E1}$) had had consistently higher mean scores in Biology compared to group II (C_1).

3.1 Effects of ECAI approach on learners' Achievement in Biology

To determine whether there was a difference in achievement in Biology between learners exposed to ECAI and those exposed to regular approaches post-test mean scores of the BAT were analysed. Hypothesis Ho1 sought to establish whether there were significant difference in achievement in Biology between learners exposed to ECAI and those exposed to regular approaches. Table 3 shows the post-test BAT mean scores obtained by the four groups.

Table 3. Post-Test BAT Mean Scores in the Study Groups

Group	N	Mean	*SD*
E_1	46	34.57	10.10
E_2	36	36.08	10.60
C_1	38	25.61	8.78
C_2	36	27.39	10.52

Table 3 shows that mean scores for E_1 was (M = 34.57, SD = 10.10), E_2 (M = 36.08, SD = 10.60), C_1 (M = 25.61, SD = 8.78) while C_2 (M = 27.39, SD = 10.52). This shows that the mean scores for E_1 (M = 34.57, SD = 10.10), and E_2 (M = 36.08, SD = 10.60), are higher compared to those of C_1 (M = 25.61, SD = 8.78) and C_2 (M = 27.39, SD = 10.52). A one way ANOVA procedure was used to establish whether there was a statistically significant difference in mean scores among the four groups. The results are shown in Table 4.

Table 4. One way ANOVA of the Post-Test Scores on the BAT

Scale	Sum of Squares	*df*	Mean Square	*F*-ratio	*p*-value
Between Groups	3089.388	3	1029.796	10.266	0.000*
Within Groups	15247.69	152	100.314		
Total	18337.08	155			

* Significant at .05 level.

Table 4 shows the ANOVA results of the post-test scores on BAT. The difference in achievement between the four groups was significant, $F\ (3,152) = 10.266, p<0.05$.

ANCOVA procedure was used to cater for initial differences between the experimental and control groups using KCPE marks as the covariate. The mean scores were adjusted using KCPE marks. Table 5 shows the adjusted mean scores

Table 5. Adjusted BAT Mean Scores Obtained by the Learners

Group	Mean	SD
E_1	35.53	1.54
E_2	35.93	1.66
C_1	25.79	1.62
C_2	27.18	1.67

The results in Table 5 shows that experimental group 1 (E_1) had a mean of (M = 35.53, SD = 1.54), E_2 had (M = 35.93, SD =1.66) which is higher than that of control group 1(C_1) which had a mean of (M = 25.79, SD = 1.62), and control group 2 (C_2) had (M = 27.18, SD = 1.67).

To confirm if experimental and control groups were significantly different ANCOVA procedure was used. Table 6 shows the ANCOVA results.

Table 6. ANCOVA of the Post-Test BAT Scores with KCPE Marks as the Covariate

Source	Sum of squares	*Df*	Mean squares	*F*	*p*-value
Learning approach	3284.622	3	1094.874	11.018	0.000*
Error	14607.761	147	99.373		

Table 6 reveals that the difference between the two groups (E_1 and C_1) is significant, F (3, 147) =11.018, $p<0.005$.

To determine which groups had significant mean differences in achievement in Biology, a post hoc test of multiple comparisons using Scheffe's method was used. Scheffe's method was preferred since the sizes of the samples selected from the different populations were not equal. Table 7 shows the results of Scheffe's post hoc test of multiple comparisons.

Table 8. Scheffe's Post hoc Multiple Comparison of BAT Post-Test Mean Scores for the Study Groups

Groups	**Mean difference**	***p*-value**
E_1 Vs E_1	-0.401	0.860
C_1	9.734*	0.000
C_2	8.350*	0.000
E_2 Vs E_1	0.401	0.860
C_1	10.136*	0.000
C_2	8.751*	0.000
C_1 Vs E_1	-9.734*	0.000

E_2	-10.136*	0.000
C_2	-1.385	0.553
C_2 Vs E_1	-8.350*	0.000
E_2	-8.751*	0.000
C_1	1.385	0.553

The results in Table 8 indicate that the pairs of BAT scores of E_1 and C_1, E_1 and C_2, E_2 and C_1, E_2 and C_2, C_1 and E_1, C_1 and E_2, C_2 and E_1, C_2 and E_2 were significantly different at the alpha level 0.05. However the mean scores of E_1 and E_2 and C_1 and C_2 were not significantly different at the alpha level 0.05. This implies that the experimental groups taught using ECAI had higher mean scores than the control groups taught using the regular approaches.

Effect size statistics was computed from ANOVA and used to indicate the impact of treatment on the outcome. Effect size (strength of association) shows the amount of the total variance in the dependent variable that is predictable from knowledge of the levels of the independent variable

Effect size using Eta squared = Sum of squares between groups/Total sum of squares

= 389.388/18337.08

= 0.168

The results indicate that the effect size was large. Cohen classifies 0.01 as a small effect, 0.06 as a medium effect and 0.14 as a large effect. This implies that as much as the mean scores of experimental and control groups were not significant. There was an impact of treatment on the outcome.

In order to determine whether there was a difference between experimental groups (E_1 and E_2) and control groups (C_1 and C_2), a t-test was computed. Table 9 shows the t-test results of the post-test mean scores of experimental and control groups.

Table 9. Independent Sample t-Test of Post-Test Mean Scores of Experimental and Control Groups

Group	N	Mean	*SD*	*df*	*t*-value	*ρ*-value
Experimental	82	35.23	1.29	154	5.471	0.000*
Control	74	26.47	9.64			

Table 9 shows that mean scores for Experimental group (E_1 and E_2) were ($M = 35.23$, $SD = 1.29$) while control groups (C_1 and C_2) were ($M = 26.47$, $SD = 9.64$) $t\ (154) = 5.471$, $p<0.05$. This shows that there was significant difference in the mean scores between experimental and control groups, in favour of the experimental group.

Effect size was computed from t-test statistics and used to indicate the impact of treatment on the outcome.

Cohen's d = $t[(n_c + n_t)/(n_c.n_t) \text{ x } (n_c + n_t)/(n_c + n_t - 2)]^{1/2}$

Cohen's d = $5.471[(82 + 74)/(82 \text{ x } 74) \text{ x } (82 + 74)/(82 + 74 - 2)]^{1/2}$

= 0.161

The results indicate that the effect size was large.

A further comparison was needed to check the mean gain of the learners in the pre-test and post-test for the experimental group 1(E_1) and control group 1(C_1). The results are shown in Table 10.

Table 10. Mean Scores and Mean Gain in BAT of Experimental and Control Groups

Stage	Scale	Group	
		E_1 N = 43	C_1 N = 39
Pre-test	Mean	20.16	14.39
	Standard Deviation	5.79	6.24
Post-test	Mean	34.57	25.61
	Standard Deviation	10.10	8.78
	Mean Gain	14.41	11.22

Equality of variances assumed (F = 0.140, p>0.5).

The results in Table 10 shows that mean scores of experimental group 1 (E_1) in the pre-test had (M = 20.16, SD = 5.79) and in post-test (M = 34.57, SD = 10.10) hence a mean gain of 14.41,which is higher than that of control group 1 (C_1). Control group 1(C_1) in the pre-test had (M = 14.39, SD = 6.24) and in post-test (M = 25.61, SD = 8.78). Hence a mean gain of 11.22. In order to establish whether the difference in mean gain scores of experimental group 1(E_1) and control group 1(C_1) were significant, a paired sample t-test was used. Table 11 shows the results of independent sample t-test of mean gain scores by learners in BAT.

Table 11. Independent Sample T-Test of Mean Gain Scores of BAT between E_1 and C_1

Group	N	Mean Gain	*SD*	*Df*	*t*-value	*p*-value
E_1	43	14.41	1.12	79	1.701	0.093
C_1	38	11.22	10.19			

* Significant at .05.

Table 11 shows that mean gain scores of E_1 and C_1 are not significantly different, t = 1.701, p>0.05. These suggest that the ECAI enhanced achievement as well as regular approaches. Thus the group that was taught using ECAI had higher mean gain scores than the group taught using regular approaches, but the differences were not significant. The hypothesis that there is no statistically significant difference between learners exposed to ECAI and those exposed to regular approaches was thus rejected at the alpha level 0.05.

4. Discussion

The results of this study indicate that the ECAI approach resulted in higher student achievement in Biology test scores than those taught using regular approaches. The significant improvement in scores for groups taught using ECAI over those taught using regular approaches are in consonance with other experimental studies demonstrating effectiveness of Experiential learning and computer assisted instructions in the teaching of Biology and other science subjects. Okechukwu (2013), in a study on the effects of experiential learning strategy on secondary school learners ’ achievement in Biology revealed that experiential learning is superior to the regular approaches in enhancing learners achievement in Biology. Ugwuadu and Joda (2013) found that learners taught with computer mediated learning performed better in class than the learners exposed to regular approaches. A study by Abdul, Balogun and Yahaya (2014) to investigate the impact of Computer Based Test in enhancing learners ’ academic achievement, its acceptance and how it can be improved upon, reported a significant positive relationship between computer use and academic achievement. Aremu and Sangodoyin (2010) in their study on the effects of computer animation on academic achievement of Nigerian senior secondary school learners in Biology observed that Computer animations were effective in improving learners ’ achievement in Biology.

A study by Rono, Wachanga, and Keraro (2013) on the effects of Computer Based Mastery Learning (CBML) on learners’ achievement demonstrated that experimental group taught using CBML outperformed the group taught using regular approaches. A study by Kiboss and Tanui (2013) on the impact of the e-learning investigation model on learners ' understanding of classification of organisms in school Biology shows that the regular group learners were outperformed by experimental group learners. A Computer Based Physics instruction program on pupils’ understanding of measurement concepts and methods associated with school science promoted pupil’s understanding of measurement concepts and skills (Kiboss, 2002). Wekesa (2003) reported that learners taught using CBI simulation performed better on cell division in Biology than their counter parts in regular program.

5. Conclusion

Based on the findings of the study, it is concluded that: The use of ECAI approach enhanced learners’ achievement more than the regular teaching approaches. ECAI is thus, an effective approach in enhancing learners ‘achievement in Biology.

6. Recommendation

The findings of this study have indicated that the use of ECAI in the teaching of Biology in secondary schools results in higher learners' achievement in Biology. This would, therefore, imply that its incorporation in teaching would boost the learning of Biology in schools. This in turn would improve the low achievement at KCSE Biology examinations. Kenya Institute of Curriculum Development, Inspectorate of Quality Assurance and Standards in education, and also designers of information communication and technology programmes, should promote the use of ECAI in Biology lessons and probably other science subjects in their attempts to improve the outcomes in Biology. To encourage teachers to use the new approach, teacher training institutions such as universities should also integrate the ECAI principles into their teaching curricula.

References

Abdul, R. A., Balogun, N. A., & Yahaya, I. S. (2014). Information Technology Enhances Learners' Academic Performance: A case of University of Ilorin. *The online Journal of Distance Education and e-learning*, *2*(2).

Adoye, O. R. (2014). Experiential and Observational Learning Techniques and their effect on Secondary School Biology Learners' Attitude towards Environmental Degradation. *Journal of education and leadership development*, *6*(2).

Ahmad, F., & Aziz, J. (2009). Learners' perceptions of a teachers' teaching of literature secondary school learners ' achievement in social studies. *Journal of Research in Education Psychology*, *16*(3), 691-708.

Alsop, S., & Hicks, K. (2001): *Teaching Science. A Handbook for Primary and Secondary School teaching*. Bell & Bain Ltd. Glasgow.

Aremu, A., & Sangodoyin, A. (2010). Computer animation and the academic achievement of Nigerian Senior Secondary School Learners in Biology. *Journal of the Research Center for Educational Technology (RCET)*, *6*(2), 146-161.

Barker, A. C., Jensen, P. J., & Kolb, D. A. (2002). *Conversational Learning: An Approach to Knowledge Creation*. Quorum, Westport, CT.

Bligh, D. (2000). *What's the Use of Lectures*. San Francisco, CA: Jossey-Bass.

Booth, M. (1994). Cognition in history: ABritish perspective. *Educational Psychologist*, *29*(2), 61-69. https://doi.org/10.1207/s15326985ep2902_1

Borg, M., & N. Stranahan. (2002). Personality type and student performance in upper level economics courses: The importance of race and gender. *Journal of Economic Education*, *33*(winter), 3-14. https://doi.org/10.1080/00220480209596120

Borg, W. R., & Gall, M. D. (2000). *Educational Research: An Introduction* (5th ed.). White plains, NY: Longman.

Bush, G. (2006). Learning about learning: From theories to trends. In *Teacher Librarian* (Vol. 34).

Caldwell, J. E. (2007). Clickers in the large classroom: Current research and best-practice tips. *CBE Life Sciences Education*, *6*(1), 9-20. https://doi.org/10.1187/cbe.06-12-0205

Canhorto, A. I., & Murphy, J. (2016). Learning from Simulation Design to Develop Better Experiential Learning Initiatives: An Integrative Approach. *Journal of marketing education*, *38*(2), 98-106. https://doi.org/10.1177/0273475316643746

Chabay, R. W., & Sherwood, B. A. (1992). *Computer-Assisted Instruction and Intelligent Tutoring Systems: Shared Goals and Complementary Approaches*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Changeiywo, J. M. (2000). Gender perspective in science and technology in Kenya. *Journal of Education and Human Resource*, *1*(1), 14-31.

Cotton, K. (2001). *Computer-assisted instruction*. Retrieved July 6, 2002, from http://www.nwrel.org/scpd/sirs/.5.cu10.html

Curtin, E. (2005). Instructional styles used by regular classroom teachers while teaching recently mainstreamed ESL learners: Six urban middle school teachers in Texas share their experiences and perceptions. *Multicultural Education*, *12*(4), 36-42.

Curtis, C. M., & Howard, M. K. (1990). *A comparison study of the Effectiveness of CAI and Traditional Lecture Techniques as Method of staff Development for Nurses*. Retrieved from http://www.widowmakers.com

Dewey, J. (1938). *Experience and Education*. Macmillan. New York, NY.

Feldon, D. F. (2007). Congnitive lead in the classroom. The double edged sword of automaticity. *Educational psychologist*, *42*(3), 123-137. https://doi.org/10.1080/00461520701416173

Firth, I. (1972). Simulated experiments in Engineering: A pilot evaluation. TERC R&D Papers, 72/70. *Tertiary Education Research Centre* ((UNSW)), Kensington.

Fraser, B. J., & Walberg, H. J. (1995). *Improving Science Education*. National society for the Study of Education (NSSE). Illinois.

Froyd, J. E. (2007). *Evidence for the efficacy of student-active learning Pedagogies*. Retrieved from http://cte.tamu.edu/programs/flc.php on 22/9/2012

Holley, D., & Dobson, C. (2008). Encouraging student engagement in a blended learning environment: The contemporary learning spaces. *Learning, Media and Technology*, *33*(2), 139-150.

Kaagan, S. S. (1999). *Leadership Games: Experiential Learning for Organizational Development*. Sage, Thousand Oaks, CA.

Kayes, D. S. (2002), Experiential learning and its critics: Preserving the role of experience in management learning and education. *Academy of Management Learning and Education*, *1*, 137-149. https://doi.org/10.5465/amle.2002.8509336

Kenya National Examinations Council. (2007). *Kenya Certificate of Secondary Education Examination Report*. Nairobi: KNEC

Kenya National Examinations Council. (2017). *Kenya Certificate of Secondary Education Examination*

Report. Nairobi: KNEC

Keraro, F. N., Wachanga, S. W., & Orora, W. (2007). Effects of cooperative concept mapping teaching approach on secondary school learners' motivation in Biology in Gucha District Kenya. *International Journal of Science and Mathematics Education*, *5*(1), 111-124. https://doi.org/10.1007/s10763-005-9026-3

Keter, J. K., & Wachanga, S. W. (2013). Relative effects of cooperative mastery learning teaching approach on learners ' motivation to learn Chemistry in Secondary schools in Bomet, County Kenya. *International Journal of Social Science and Interdisciplinary Research*, *2*(11), 196-207.

Kiboss, J. K. (2002). Impact of a computer based physics instruction program on pupils' understanding of measurement concepts and methods associated with school science. *Journal of Science Education and Technology*, *11*(2), 193-198. https://doi.org/10.1023/A:1014673615275

Kiboss, J. K., & Tanui, E. K. (2013). Effectiveness of e–Learning Investigation Model on Learners 'Understanding of Classification of Organisms in School Biology. *Journal of Education and Practice*, *4*(7).

Kinya, J., & Wachanga, S. (2015). Effects of Experiential Concept Mapping Teaching Strategy on Learners' Motivation in Chemistry in Imenti South District, Kenya. *Journal of education and human resources*, *7*(2).

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. New Jersey: Prentice-Hall.

Lai, C. H., Yang, J. C., Chen, F. C., Ho, C. W., & Chant, T. W. (2007). Affordances of mobile technologies for experiential learning: The interplay of technology and pedagogical practices. SPECIAL ISSUE Original article. Learning. *ELT Journal*, *53*(4), 66-80. https://doi.org/10.1111/j.1365-2729.2007.00237.x

Lewis, J., & Kattmann, U. (2004). Traits, genes, particles and information: Re-visiting learners 'understanding of genetics. *International Journal of Science Education*, *26*, 195-206. https://doi.org/10.1080/0950069032000072782

Liang, Q. (2004). A shift from traditional teacher-centered strategy to student-centered strategy in genetics teaching. *The china papaers*.

Lockard, J., Abrams, P. D., & Many, W. A. (1987). *Microcomputers for Educators*. Boston:

McMullan, W. E., & Cahoon, A. (1979). Integrating abstract conceptualizing with experiential learning. *Academy of Management Review*, *4*, 453-458. Available on ABI/Inform Global database. https://doi.org/10.5465/amr.1979.4289132

Miettinen, R. (2000). The concept of experiential learning and John Dewey's theory of reflective thought and action. *International Journal of Lifelong Education*, *19*(1), 54-72. https://doi.org/10.1080/026013700293458

Millenbah, K. F., & Millspaugh, J. J (2007). Using Experiential Learning in Wildlife Courses to Improve Retention, Problem Solving and Decision Making. *Journal Storage*, *31*(1), 127-137.

Mills, H. R. (1991). *Teaching and Training: A handbook for instructors* (3rd ed.). London: Macmillan Publishers.

Ministry of Education. (2001). *National Report on the Development of Education in Kenya presented at the International Conference on Education 46th session, Geneva, 5-7th September*. Retrieved from http://www.ibe.unesco.org/International/ICE/natrap/Kenya.pdf

Mugiria, A., Wachanga, S., & Mbugua, Z. (2015). Effects of Advance Organizer Teaching Approach on Secondary School Learners' Self-Concept in Chemistry in Maara Sub County, Kenya. *Journal of education and human resources*, *7*(2), 14-19.

Okechukwu, A. (2013). *Effects of experiential learning strategy on secondary school learners' achievement in Biology*. Conference paper presented at world conference on science and Technoloy Education, at Sarawak, Borneo, Malaysia.

Orende, W., & Chesos, R. (2005, May26). Radical Changes made in KCSE. *The Daily Nation Nairobi, Kenya: Nation Media Group Ltd* (p. 48).

Pal, J., Stubbs, M., & Lee, A. (2005). Designing a web-driven retail marketing simulation. *Journal of Marketing Management*, *21*(1), 835-858. https://doi.org/10.1362/026725705774538435

Ronoh, P. K., Wachanga, S. W., & Keraro, F. N. (2013). Effects of Computer Based Mastery Learning on Secondary School Learners Achievement in Biology in Bomet district, Kenya. *International Journal of social science & interdisciplinary research*, *2*(12).

Sander, P., Coates, D., King, M., & Stevenson, K. (2000) University learners' expectations of teaching. *Studies in Higher Education*, *2*(3), 309-323. https://doi.org/10.1080/03075070050193433

Shihusa, H., & Keraro, F. N. (2009). Using advance organizers to enhance learners' motivation in learning Biology. *Eurasia Journal of Mathematics, Science and Technology Education*, *5*(4), 413-420. https://doi.org/10.12973/ejmste/75290

Smith, L. (2001). Content and delivery: A comparison and contrast of electronic and traditional MBA marketing planning courses. *Journal of Marketing Education*, *23*(1), 35-44. https://doi.org/10.1177/0273475301231005

Ugwuadu, O. R., & Joda, F. M. (2013). Effectiveness of computer-based instruction on academic performance of pre-degree learners in Biology, abdullahi, shuaibu. *Public policy and administration research*, *3*(12), 104-109.

UNESCO. (1986). *A Handbook for Biology teachers in Africa*. Paris.

Vaidya, N. (2003). *Science Teaching for 21st Century*. New Delhi: Deep & Deep Publication PVT. Ltd.

Wambugu, P. W., & Changeiywo, J. M. (2008). Effects of Mastery Learning Approach on Secondary School Learners' Physics Achievement. *Eurasia Journal of Mathematics, Science and Technology Education*, *4*(3), 293-302. https://doi.org/10.12973/ejmste/75352

Wekesa, E. (2003). Improving Learners' Understanding and Perception of Cell Theory in School Biology Using a Computer-Based Instruction Simulation Program. *Journal of Educational Multimedia and Hypermedia*, *15*(4).

Wekesa, E., Kiboss, J., & Ndirangu, M. (2006). Improving Learners' Understanding and Perception of Cell Theory in School Biology Using a Computer-Based Instruction Simulation Program. *Journal of Educational Multimedia and Hypermedia*, *15*(4).

Yusuf, M. O., & Afolabi, A. O. (2010). Effects of Computer Assisted Instructions on secondary school learners' performance in Biology. *Turkish online Journal of Educational Technology*, 62-69.