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The effectiveness of computer-assisted learning on student achievement in Biology subject in selected school in Uasin Gishu County, Kenya.

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Abstract
Background: *Unsatisfactory performance outcomes in science education in secondary schools calls for a review of the teaching approaches used in ensuring that students acquire scientific knowledge concepts with ease. However, the performance of Biology subject in the national examination inKenya is unsatisfactory, thus, warrantingthe need for innovative teaching strategies. Despite the increasing adoption of ICT in science education in several schools in Kenya, evidence to support its use for teaching is limited and inconclusive.Due to the dearth in studies in the local context, the study sought to examine how Computer Assisted Learning (CAL) or Computer-Aided Instruction(CAI) can aid in the teaching of mutations in a form four Biology course in a selected secondary school in Uasin-Gishu County. The concept of mutations is under the wider topic of Genetics. Mutations are generally abstract as there are no experiments that can be done by students in the laboratory to observe the actual processes of mutations occurring in cells.*
Materials and Methods*: The study explored the effectiveness of Computer Assisted Learning (CAL) in the teaching mutations in a form four Biology course in a selected secondary school in Uasin-Gishu County by comparing computer-assisted learning with conventional teaching methods. The study used an experimental design and employed a Pretest-Posttest control group design to compare the experimental group (E) and the control group (C) at Kerotet Girls High School in Uasin-Gishu County. A simple random sampling was used to select 54 students and placed them into experimental and control groups where each group had 27 students. First, the study measured the attitudes of the students towards biology using a conventional tool before assigning the students to the groups. The experimental group were taught using CAL while the control group were taught using conventional methods (lecture and discussion). The concept was taught in 5 lessons each lasting one hour over a period of oneweek. The study used a Biology Achievement Test (BAT) to score the students' achievement. The data generated were entered into statistical software and analyzed using descriptive and inferential statistics. Importantly, t-test was conducted at ά= 0.05 significances level of significance.*
Results: *At the onset, there were no differences between the groups (t = 0.67, P> 0.5) but the standard achievement scores at the end of the experiment increased drastically for the experimental group and significant differences between groups were detected (t = 10.89, p< 0.05). Thus, the students exposed to CAL lesson performed significantly better on the BAT,however, this finding must be interpreted with caution in light of sample size.*
Conclusion: *The computer-assisted learning module was an effective strategy for teaching both the theory and practice in mutations lesson in biology subject to secondary school students in Kenya as it was found to be at least as effective as conventional face-to-face teaching methods. The study recommends teacher training programs should incorporate computer studies in order to enable teachers to design CAL lessons to improve teaching andlearning*
Keywords: *computer-assisted education; Computer-assisted instruction; computer-assisted learning; learning styles; student achievement score.*

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I. Introduction

Biology occupies a unique position in the curriculum and is central to many science-related courses such as medicine, pharmacy, agriculture, nursing, biochemistry and many others (Yusuf & Afolabi, 2010) and therefore students view scientific knowledge as an important component of their education, acknowledging its value for explaining everyday experience (Christidou, 2011).However, the conventional approach to teaching science being offered in schools fails to effectively prepare students for their experience of science beyond school and to present science as a fascinating, interesting and rewarding subject at the fulcrum of human

existence (La Velle, McFarlane & Brawn, 2003).Science education in secondary schools contains many theoretical and abstract concepts, which may be difficult to understand, therefore students need visualization and modelling (Tekbiyik & Akdeniz, 2010). The increasing number of students pursuing degrees in STEM (science, technology, engineering, and mathematics), calls for improvements in techniques for teaching mathematics and science education (Maltese & Tai, 2011).

Learning or achievement outcomes is also predicted by the students' approaches to learning(García et al., 2016; Sengodan & Zanaton, 2012).Because of the need for achievement in terms of good assessment and grades, students would use different kinds of learning approaches that may be suggested to them by their instructors (Schittek et al., 2001).This is illustrated by a meta-analysis which was conducted by Schroeder et al., (2007) which reported that several teaching strategies had a substantial effect on the student's achievement. In support, Savelsbergh et al., (2016) reported that different teaching strategies have a significant effect on the general attitudes of the students towards science education. The study reported the effect was weaker for the older student but overall, there was significant large effect in achievement outcomes.

The advancements in technology have changed the tools, communication, information, and the nature of work (Jang & Tsai, 2013) and thisadvances in technology and the increasing application of technology-rich environments in educational settings have provoked discussions of assessment (Shute & Rahimi, 2017). In developing economies, the use of computing technologies can supplement teaching efforts at schools which have shortages of teachers and is therefore considered a cost-effective solution to bridging the educational gap (Mo et al., 2015) and is can therefore be used for improving the quality of education in developing countries (Linden, Banerjee & Duflo, 2003). ICT in teaching favours several processes related to teaching and learning – in particular, those involving attention, perception, responding mechanisms, application of learning and understanding(Sangrà & González-Sanmamed, 2010). In science education it helps learners develop novel strategies for problem-solving by building models and creating new rules (La Velle, McFarlane & Brawn, 2003).

Several studies have highlighted the potential benefits of information and communication technologies (ICT) for improving educational outcomes (Sangrà & González-Sanmamed, 2010).The advances in the learning sciences indicate that acquiring and demonstrating new knowledge and skills occurs within an environment or pedagogical context, which includes learners with specific cognitive and emotional profiles and tools to promote and evaluate student learning (Shute & Rahimi, 2017).Further, the cognitive tools embedded in ICT and the pedagogical content knowledge involved provide a powerful driver for the knowledge transformation that enables students to understand a new problem (La Velle, McFarlane & Brawn, 2003).

The use of computers in teaching and learning activities is defined as Computer-Based Instruction (CBI) or computer assisted learning (CAL) (Serin, 2011) and is part of learning environmentexpressesthe effects in a social context with a rich, multimedia and multimodal learning environment (La Velle, McFarlane & Brawn, 2003).This technique is referred to as computer Based Instruction (CBI), Computer-Aided Learning (CAL), or Computer-Aided Instruction (CAI) (Schittek et al., 2001).CAL heavily relies upon the computer-assisted instruction (CAI) which involves the use of ICT components to strengthen the learning processes (Tekbiyik & Akdeniz, 2010). Computer Assisted Learning (CAL) which is increasingly referred to as the learning procedures and environments facilitated through computers. Owing to the popularity and advances in computer and network technologies, CAL/CAI learning approaches has attracted the attention of researchers (Hwang, Shi & Chu, 2011).

ICT components have become an integral part of our education system and influences the education system at different levels and each stage of education by enhancing the efficiency of the teaching-learning process, making students more attentive, confident and providing each student with an individualized learning environment to learn at one's own pace (Kumari, 2018). The successful use of ICT can produce a change in pedagogical practice (La Velle, McFarlane & Brawn, 2003) as learners acquire scientific concepts in an easy meaningful manner which enables them to makes use of these concepts in their daily lives (Serin, 2011). The use of audio-visual devices and animations with instructional materials results in an enjoyable and productive learning process (Serin, 2011).

There is also individualized computer-based instruction, games, feedback, interactive quizzes, computer-based labs, simulations and robotics (Savelsbergh et al., 2016), shortened learning and absorption time, better outcomes other aspects (Schittek et al., 2001).CBI enables the students to learn by self-evaluating and reflecting on their learning process and provides them with the immediate feedback and reinforcement and by creating an exciting and interesting game-like atmosphere (Serin, 2011). CAL promotes learning by allowing learners to take absorb more responsibility in the choice, regulation and evaluation of learning activities at any time, place and means (Županec, Miljanović & Pribićević, 2013).

The multimedia components of CAL combine audio and visual data in an interactive form and supplement and reinforce more traditional learning and create opportunities for illustrating concepts situations in an interactive way. CAL method provides the learners with a variety of knowledge sources and medium from which they can experiment (Morgil et al., 2005). Other important elements of CAL are the use of a variety of

features that include the use of vivid and animated graphics, enabling three-dimensional aspects which makes learning interesting. These aspects are hardly available in the didactic classroom situation (Morgil et al., 2005). Teachers have emphasized the importance and necessity of simulated or authentic activities where students can work with real-world problems or develop the model (Hwang, Shi & Chu, 2011).

CAL transforms knowledge into a positive constructivist learning environment. The use of ICT resources during the CAL is part of that learning environment, and their effects are expressed in a social context with a rich, multimedia and multimodal learning environment (La Velle, McFarlane & Brawn, 2003).CAL also ensured that students learn more about the underlying scientific processes using models generated by education software than they do in the laboratory (La Velle, McFarlane & Brawn, 2003).It also enhances the learning task maybe even more vital by providing text, graphs, audio, video, pictures, animation and simulation in the same medium to studentsby providing drawings, graphics, animation, music and plenty of materials for the students to proceed at their own pace and in line with their differences (Tekbiyik & Akdeniz, 2010).

The use of computer-assisted learning techniques has several advantages that include: flexibility and the promotion of active learning, improvements in student motivation and satisfaction, cost efficiency and reductions in instructional time and consistency of educational delivery. Computer-assisted learning tends to individualize learning by decentralizing the teaching process and facilitating learner independence and direction (Bloomfield, Roberts & While, 2010). Computers facilitate interaction during the learning process on multiple levels. At one level, it involves the interaction of the students with the content and the learning material. On another level, computers host interaction of the students with the tutor, peer interaction or interaction virtual learning communities (Schittek et al., 2001).

A study by Shute and Rahimi (2017) indicated that the use of CAL in instruction generally enhances learning and other outcomes across a range of content areas such as biology, mathematics and programming. In a study, Huang, Liu &Chang (2012) established that CAL improved the mathematical problem – solving skills of low-achieving second-and third-graders. Chang, Sung &Lin (2006) established that the use of mathematical CAL was effective in improving the performance of students with lower problem-solving ability.The use of CAL in improved the academic scores of the 4th-grade student in Multiplication of Natural Numbers, Division of Natural Numbers, and Fractions (Pilli & Aksu, 2013). CAL increases students' achievement when the technique supplements normal conventional teaching methods and is more effective to the underachievers (Serin, 2011). Linden, Banerjee & Duflo, (2003) found that the CAL program significantly improves math test scores, with most of the gains occurring in the second part of the year.

Empirical studies have reported high skill performance scores for students who use CAL as compared to conventional learning methods (Bloomfield, Roberts & While, 2010). In an experimental study using CAL, Morgil et al., (2005) observed that the use of CAL in teaching chemistry subject lesson on acids and bases resulted in 52% improvements in post-instruction test results. The results were significant and indicated that the use of CAL tends to result in improved test scores when compared to conventional teaching strategy.A meta-analytical study that examined the overall effectiveness of the CAL reported that the average student's achievement in science learning for learners using CAL rose significantly. This indicates that CAL influences the student's achievement scores (Tekbiyik & Akdeniz, 2010). Mo et al., (2015) reported that the CAL math programs improved student self-efficacy improved by 0.08 standard deviations

The performance in Biology subject has not been satisfactory and has indicated by the reports the average scores (standard deviation) for the last four years are 58.37(35.16), 37.85(23.45), 51.38(23.26) and 55.32(20.65) marks (KNEC, 2020). This indicates an average pass mark for all the students taking biology as a subject in secondary schools in Kenya. A report by the Standard media group indicated that the performance in the biology subject for three consecutive years has been on a downward trend with only a small number getting grade B and above. The trend is raising concerns that many bright students will be locked out of studying sciencecourses (Standard Media, 2019).

There is a general tendency across studies on innovative teaching approaches to have positive effects, there is little clarity on how these interventions cause effects on outcome, and under what conditions (Savelsbergh et al., 2016).Extant literature has examined the factors determining academic achievement in mathematics and science education (García et al., 2016) but the empirical research in high school educational stages in Sub-Saharan Africa remains scarce. And as elaborated by the foregoing reviews, there is a need to evaluate the different pedagogical strategies used in science education in the high or secondary school level.

CAL application in biology teaching is little known in the country and is therefore insufficiently applied in biology teaching in the education system, therefore, the study sought to examine the effectiveness of CAL on student achievement in Biology subject selected secondary schools in Uasin Gishu County, Kenya.

Method

Aim

The primary aim of the study was to compare the effects of a CAL module with conventional face-to-face classroom teaching on the acquisition and retention of concepts of mutation by selected secondary school students in Uasin Gishu County, Kenya. The null hypothesis for the study was that; there is no significant difference in the performance in biology subject betweenstudents taught the concept of mutations using CAL and those taught using conventional methods.

Participants

The study was located in Kerotet Girls high school which is found in Uasin Gishu County, Kenya and had a total number of 154 form four students. From this population, 35% of them (54) were clustered into three homogenous subgroups based on their intellectual abilities of above average, average and below average. The stratification was based on theaverage mark for Biology for each student for three school terms; second and third term of form three work and the first term of form four work. A formal sample size calculation was not undertaken due to a lack of information from previous studies, however, strenuous efforts were made to use the most appropriate sample size.Fifty Students who had an average score of over 60% were placed above the average category and from these 18 students from this category were enrolled in the experiment. Eighty- two students who had a score of between 50 and 60% were placed in the average and from which 29 students were randomly enrolled in the study. Lastly, 22 students whose scores were below 50% were placed in the below-average and out of which seven students were randomly selected for the enrolment into the experiment.

Lastly, the 54 students who were enrolled in the experiment were split into either the experimental and control group. After recruitment, participants were sequentially allocated a number which became their unique code. A computerised random number generator was then used to assign participants to the intervention (CAL) or control (conventional teaching method) group using these codes. The two groups were then taught separately, with the experimental group being taught using CAL while the control group was taught using the conventional methods. The teaching of the concept of mutations was done outside the normal class hours (5.00 pm-6.00 pm) to minimize class disruptions. The experimental group was taught by the researcher in the computer laboratory while the control group was taught with the other students who had not been chosen for the study in their respective classes.

Design

The study used the experimental design known as the Pre-test – Post-test Control Group design. An attitudinal test was conducted into both groups to gauge their attitudes towards biology, after which a pre-test was administered to both groups. Data were collected at three points during the study between May 2018 and July 2018. Baseline data, generated from a student attitude questionnaire and biology achievement test, were collected from all participants immediately before the teaching intervention. The biology test was repeated immediately following the teaching session. The biology achievement test (BAT) was assessed at both the onset and end of the experiment.

Teaching Intervention

The two teaching methods were compared. Both were expected to take one hour daily for a period of five days or 300 minutes duration and were designed to facilitate the acquisition of concepts of mutation.

Conventional module

The participants in the control group (n = 27) were taught in anormal classroom setting by the subject teachers. This involved a standardised teaching pack which contained: asecondary school biology curriculum; a set of secondary school biology, shorthand notes on mutation, chalks and blackboard. Any questions about the subject matter which arose during the session were answered by the researcher who was also a science teacher in the school.

The evaluation questions at the end of each lesson were also prepared using the same textbooks. A lesson plan for each lesson was then prepared. Each lesson lasted for one hour daily and the whole concept of mutations was taught over a period of five days (300 minutes). The concept of mutations has been allocated seven lessons in the syllabus and each lesson takes 40 minutes. In total the whole concept is covered on 280 minutes. The researcher tried as much as possible to operate within the time allocated

CAL module

The participants in the experimental group (n = 27) were taught using a specific computer-assisted learning (CAL) module. The participants in the experimental group were knowledgeable in computing technology and therefore they were expected to complete the study under the instruction of the researcher. The

CAL lesson was developed in line with the objectives outlined in the KNEC syllabus. Videos on mutations were downloaded from the internet and the ones relevant to this study were selected. The researcher then drew diagrams of crosses showing inheritance of various traits resulting from mutations using the computer. Short notes explaining each type of mutation were prepared using various textbooks such as secondary school biology book four by Kenya literature bureau, longhorn biology book four, comprehensive biology book four and principles of biology volume two.

The CAL lesson was developed and used to instruct the 27 students selected into the experimental group. CAL consisted of 5 lessons taught over a period of one week. Each lesson lasted for one hour. The lesson contained instruction on the two types of mutations, that is the chromosomal and gene mutations and the disorders associated with these types of mutations. The CAL lessons comprised of animations, computer illustrations and brief explanations. After going through the lesson, the students discussed what they had learnt in groups of two and made brief notes. There were evaluation questions at the end of each lesson that the students answered and handed over formarking.

At the onset of the lesson, the research provided an outline of the activities for each lesson each day. The researcher always secured the computers with the password and unlocked the computers on the day of the lesson. This ensured that no student accessed the lesson in the absence of the teacher and that the control group did not access the information in the computer because both experimental and control groups were in the sameschool.

Outcome measures

Attitudinal aspects

Baseline attitudinal test was measured using a purposefully developed a test that consisted of six questions with most questions were about the agreement ('Strongly disagree' 'Strongly agree'). This was carried out to gauge the attitudinal component of the students on biology as a subject.

Achievement scores

The student's achievement scores were based on biology assessment test (BAT) which was developed and used to assess the student's achievement levels before and after the treatment. The test was marked out of 50 marks. The BAT was composed of standard questions that have been examined in the earlier national examination and tested the student's ability to comprehend, analyze and synthesize information.

Analysis

The data analysis was carried out according to a pre-established analysis plan using the SPSS (version 20) statistical software package. Expert advice was sought from an experienced statistician throughout the data analysis process. Statistical tests of a non - parametric and parametric nature were employed and a conventional level of significance of 0.05 was used to detect differences. The χ^2 analysis was used to test for differences between the study participations in the two study groups. The t-test was used to check for significant differences in the BAT test scores between the control group and the experimental group at each phase of the study and was also used to compare the performance assessment scores.

II. Findings

Biology Attitudinal change

Table 1 Descriptive statistics for pre-test scores

	Control			Experimental			Statistics	
Variable item	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**χ^2**	**p**
Biology is a boring subject	27	1.22	0.424	**25**	1.36	0.490	3.900	0.420
I like biology very much	27	4.63	0.688	**25**	4.56	0.712	5.144	0.273
Biology is aninteresting subject	27	4.67	0.480	**25**	4.64	0.490	5.487	0.241
I look forward to biology class	27	4.56	0.506	**25**	4.36	0.952	7.522	0.111
I only understandbiology during class time	27	2.41	0.844	**25**	2.04	1.020	5.583	0.232
I will drop biology now	27	1.26	0.813	**25**	1.12	0.332	3.993	0.407

Table1 shows the attitudinal aspects of the participants during the pre-test period. In terms of biology as a subject issue, the respondents strongly affirmed that they like biology and never found biology to be boring. Biology is an interesting subject and the majority of the participants look forward towards attending the biology class. The participants were indifferent to learning biology subject with or without a teacher showing that they can understand some concepts without the teacher and would not drop biology as a subject.

The statistics on Table 1 examined for any association between the study variables and gender using the chi-square distribution. The statistic, χ^2 ranged between 3.900 and 7.522 with $p > 0.05$ indicating that the were no significant differences in attitudes of both experimental and control groupparticipants. It can be inferred to mean that participants have a positive attitude towards biology thus any significant difference in achievement

scores cannot be linked to their attitudes.

Biology Achievement Test Scores

Table 2: Comparison of biology test scores between study groups

	Control group					**Statistics**	**Experimental group**				**Statistics**
	N	Mean	SD	Min	Max	t- test	Mean	SD	Min	Max	t- test
Pretest	27	31.30	5.377	20	46	t = 2.36	32.22	4.677	25	44	t = 10.89
Post-test	27	33.44	5.611	19	43	p =0.134	42.07	3.362	35	49	p = 0.016

The results as summarised in Table 2 shows the scores from the participants who completed the baseline BAT test ranged. The pre-test scores for the control group ranged between 20 and 46 with a mean of 31.30 and a standard deviation of 5.377 while those for the experimental group ranged between 25 and 44 and had a mean of 32.22 and a standard deviation of 4.677. When these scores were compared between the study groups, no significant differences emerged between the groups in the pre-test scores ($t = 2.36$, $p > 0.05$). Significantly higher scores were achieved at the immediate follow-up with the scores for the experimental group ranged between 35 and 49 with a mean of 42.07 and a standard deviation of 3.362 while the scores of the control group ranged between 19 and 43 with a mean of 33.44 and a standard deviation of 5.611. there were significant differences between the scores of the groups ($t = 10.89$, $p < 0.05$).

III. Discussion

The goal of this study was to compare the effectiveness of CAL versus conventional teaching methods on the acquisition and retention of mutation concepts in the biology subject by secondary school students in Kenya. The findings support the integrated CAL module as an alternative to a face-to-face teaching session. This finding is similar to several empirical studies which have shown that students using CAL have better learning outcomes when compared to the conventional learning technique (Schittek et al., 2001; Morgil et al., 2005; Ecalle, Magnan & Calmus, 2009; Tareef,2014; Kumari, 2018). Further support to the findings illustrates that computing technologies help lower achievers improve the achievement outcomes (Mo et al., 2015) and increases learner's achievement level with a commensurate higher performance the conventional teaching method. Thus, the use of computers in biology teaching was much more efficient than traditional teaching in terms of quality, durability and applicability of knowledge (Županec, Miljanović & Pribićević, 2013). However, other studies indicate that the adoption and usage of computing technologies have varying outcomes because of the differences in education systems in countries (Mo et al., 2015)

These findings suggest cognitive gain and knowledge retention and mastery of biology concepts implies that the study participants have the capacity to learn the theoretical abstracts that may be taught later using CAL. The achievement score was relatively high with a mean of 42 maybe attributable to the significantly higher knowledge capabilities in all the three cognitive domains of knowledge, comprehension and application. This finds support in a comparative study by Županec, Miljanović & Pribićević(2013) which indicated that pupils taught with the CAL program achieved significantly higher quantity and quality of knowledge in all three cognitive domains of knowing, applying, and reasoning than the pupils from the traditional conventional teaching method.

Further, the effectiveness of the CAL is also underpinned by the contribution of the computer-based instruction to the effectiveness of the teaching techniques in the presentation of information, testing and evaluation and providing feedback to the learner(Tareef, 2014). In essence, rote learning is minimized, thus encouraging meaningful learning to take placeIn a CAL learning environment, (Županec et al., 2013). Thus, several studies have demonstrated that students using CAL needed shorter time to reach the learning objectives and achieving better final results than students who did not have access to CAL (Schittek et al., 2001). CAL has been proven to be more efficient than the traditional methods in increasing academic achievement of learners in biology subject lessons: digestion and excretion Systems, floral Plants, reproduction of plants and animals among others (Županec et al., 2013).

IV. Conclusion

The mastery and retention of biological concepts in a biology class in a secondary school education setting are informed by relevanttheoretical knowledge which represents a crucial element in theprocess of learning. It is essential thatthe most effective teaching strategies are employed for teaching science education and that these are supported by current research. While the major findings of this study confirmprevious research in demonstrating equivalency betweenCAL and conventional teaching methods, this is in itself avaluable finding. Given the ongoing debate the increasing use of e-learningwithin education, the findings are timely and provideevidence that CAL is at least as effective as conventionalmethods when used to teach secondary school students. Therefore, Computer-based instruction should be embraced as a potentially valuable

teaching tool, especially given the possibilities of self-study and distance education. CAL allows for personalized learning, permitting students to progress at their preferred pace (Walsh et al., 2011).

Limitation

The major limitation of this study is the lower sample size which affects the generalization of study findings in larger populations.Small sample sizes tend to have considerable potential to introduce bias, which may haveinfluenced the findings. Therefore, findings from this study must be interpreted with caution, and futureresearch is recommended with a larger sample toinvestigate the effect of CAL on mastery and retention in other science education within the same context or locality.Despite this limitation, the strength of this study lies inthe use of a rigorous trial design that addressed many ofthe flaws evident in previous research.

Contribution

The study contributes to the adoption and use of the CAL/CAI in science education in a secondary school setting in Sub – Saharan Africa and thus it provides a foundation for further studies to explore the concept.

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