Computer Assisted Learning For Enhancing Mastery Of Concepts In Science

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ABSTRACT

This study examined the effects of Computer Assisted Learning (CAL) on the mastery of Science concepts by learners in universities. Teaching and learning of Science concepts present learners with numerous challenges. Of critical concern is the negative perception by learners that Science based subjects are difficult, thus contributing to widespread poor performance by the learners in the national examinations and subsequently poor choice of the subject in the universities. Solomon Four Group experimental design was employed for the study. The target population comprised all first-year students taking science subjects in 8 universities in western Kenya. A sample size of 335 students was determined using Krejcie & Morgan table (1970). The universities were divided into two forming experimental and control groups. The study was carried out in 4 months spanning 16 weeks where pretest was administered after the first 8 weeks of conventional teaching and post-test administered after the next 8 weeks of treatment. Pretest and post-test Science Achievements Test (SAT) on two topics, digestive system and light and optics, were designed and administered by the respective lecturers, and scores recorded. Piloting was carried before the use of the instruments, and a reliability coefficient of 0.85 on SAT was recorded. Data were analyzed using t-test one-way ANOVA. The study found that 171 students taught using CAL achieved significantly higher scores in SAT compared to 164 students taught through conventional methods with a mean gain of 2.051. The study demonstrated that CAL enhanced active manipulation of content and promoted interaction with content, and gave reality to abstraction. The study may be significant to educationists, lecturers, researchers, and policy makers as it provides insight on the benefits of applying Computer Assisted Learning in Science Education.

Keywords: Computer-Assisted Learning, Learners, Achievement Test, Science Concepts, Universities.

INTRODUCTION

Performance of learners in Science

The performance of learners in Science-based subjects in national examinations has largely remained poor compared to other subjects (Buindi 2013). Reports by Organization for Economic Cooperation and Development (OECD) indicated that 21% of learners across its member countries do not reach the baseline proficiency level of 2, which is the level at which learners should have acquired knowledge of basic Science content and procedures (OECD 2016). In Uganda, a study conducted by Black, Atwaru-Okello, Kiwanuka, Serwadda, Biribi, Malinga, Biumigishu, & Rodd (1998) showed that Science was a burden to the country’s education system because of lack of practical experiences and teaching facilities. Similar studies in Tanzania have also indicated poor performance in Sciences (Hamilton, Mahter, Matenge & Machumu, 2010).

In Kenya, data from the Kenya National Examination Council (KNEC), not only shows a similar trend to the other East African countries but further reveals a steady drop in achievement in Sciences over the years (Business Daily, 2019). This has affected learners choice of Science subjects in secondary
schools (Omondi, 2013; Maltese & Tai, 2011) and led to poor performances recorded in Kenya Secondary School Education (KCSE) examinations with Chemistry generating a mean of between 22.71 to 27.93, Biology 26.21 to 30.32 and Physics 31.31 to 37.86 between 2013-2017 (KNEC, 2017). The failure in the national examination has further resulted in the poor choice of science subjects for advanced studies in universities. This is because basic and secondary school Science provides the requisite background for the advanced studies of science in universities (Oduol, 2018). Poor performance in the Sciences is largely attributed to negative attitudes towards the subject (Omondi, 2013; Olatunde, 2009; Abudu & Gbadamosi, 2014), lack of teaching and learning materials (CEMASTEVA 2017), poor teaching methods (Majo, 2016), and the difficulties in comprehension and understanding of Science concepts by learners.

The long term effect posed by these challenges is a reduced number of learners pursuing Science related careers, despite the fact that Science is considered as an enabler and foundation for wealth creation and economic development across the world (UNESCO, 2005; Muzah, 2011; Kibet, Mbugua, Muthaa & Nkonke, 2012)

Computer Assisted Learning

Due to the rapid rise in development and advancement in information and communication technology (ICT), the adoption and use of computers in the advancement of education cannot be ignored. Accordingly, there has been increased uptake and integration of educational technologies such as animation, audio-visual, simulation, and use of PowerPoint presentations in classrooms to help overcome teaching challenges and improve learning processes (Jesuraja, 2015). These technologies potentially enhance learner’s academic outcomes by creating a richer environment for open and positive interaction and intuitive content delivery for better engagement and content retention by learners. Technologically, an innovative lesson is a proven gamechanger that could revitalize the education sector by promoting active learning (Bond & Bedenlier, 2019; Ainley & Engers, 2007). In addition, the use of technology has been argued, creates interest, and increases the learners’ motivation, hence playing an important role in the teaching and learning process (U.S. Department of Education, 2017)

Due to the dynamism and advancement in learner environments, there is a need for universities to continuously adopt new pedagogical approaches for sustained engagement in order to influence learner behaviours, create a sense of ownership in the learning process, stimulate their intelligence, motivate and encourage them along the academic journey (Mynbayeva, Sadvakassova & Akshalova, 2017).

Because of the increasingly poor performance in Science, several studies have been carried out to encourage the use of CAL approach to enhance learners’ grasp of Science concepts from formative to later school years. For instance, a study by Galang & Galang (2017) in computer-aided tool in Science for kindergarten pupils found that CAL was effective in enhancing learning in Science and allowed the kindergarten pupils to develop the foundation necessary for future academic success. In a different study by Bayrak & Bayram (2010), computer-assisted learning had a positive effect on the academic achievement of learners in Science and technology subjects. Tareef (2014), in his study on the effects of CAL on achievement and problem-solving skills of educational statistics, learners revealed that CAL was more effective on the learners’ achievements than the traditional instruction methods. A study by Sharma, (2017) concluded that CAL has the potential to transform the education process and improve the efficiency of learning by encouraging and motivating learners. Taken together, these studies validate findings that prove that using CAL is an effective teaching method that can stimulate learner engagement and that engaged learners are good learners (Bryson & Hand, 2007; Jang, 2008; Troisi, 2014).

Appropriate use of CAL in teaching and learning Science can be beneficial to the acquisition of scientific knowledge and its practical application (UNESCO, 2012). The use of CAL has the potential to
meets the requirements of a constructivist framework that can help learners to build and acquire knowledge and make sense of it (Ben-Ari, 2001).

The computer, as a learning tool, engages learners in interactions that build a more complete and richer recognition, recall, reconstructive, constructive, and intuitive understanding of concepts (Sharma, 2017). By so doing, CAL enables learners to internalize their thinking, perception, problem-solving, innovativeness, and manipulation of models provided by the computing system. CAL can also contribute to the acquisition of varied knowledge as well as to promote learner independence, peer learning, and the urge for schoolwork (Fafchamps & Mo, 2018). Further, CAL can enhance the lecturer’s ability to hold each learner’s attention and interest in the lessons, especially in large classes (Galang & Galang 2017). Besides, many learners are today exposed to at least a digital device at an early age thus have acquired to some degree skills to take up CAL with ease.

Because of the many benefits of CAL in Science teaching, researchers have championed its application to enrich learners’ understanding of complicated concepts of Science (Keengwe & Onchwari, 2008). For instance, in CAL approach, simulation and gamification can be used to provide an environment or aspect of reality that is otherwise not possible to explore within the confines of the classroom (Dina & Ciortnei, 2012; Sahin, 2006); teach concepts that are either difficult or dangerous (Hennessy, Wishart, Whitelock, Deaney, Brawn, Velle, McFarlane, Ruthven & Winterbottom, 2007). Use of interactive computer animation to model complex realities in the understanding of cells in Science (Cakiroglu & Yilmaz, 2017).

The rationale for the study

Despite the above benefits, limited empirical data exist on the efficacy of the use of CAL in Science in Kenyan Universities. It is on this basis that this study sought to explore the effect of CAL on mastery of Science concepts in universities with a specific focus on experimenting, observation, and drawing of inferences. The study is geared towards informing policy formulations for enhancing uptake and improving learner performance in Science with the hope that this may encourage more learners to take up science and consider a career in science-related fields. Improved performance in Science and related subjects will act as a strong pillar towards the realization and achievement of Kenya Vision 2030, the Big 4 Agenda, and the United Nations sustainable development goals.

THEORETICAL FRAMEWORK

This study was based on cognitive load theory (Sweller, 1988), which focuses on the use of instructional methods that stimulate learners ability to efficiently apply mastered knowledge and skills to solve problems while taking into account the limited cognitive processing capacity of the human brain (Sweller, 2012; Sweller, Ayres & Kalyuga, 2011). CAL could, therefore, be an appropriate instructional method because it is multi-sensory approach that involves the use of all senses that stimulate learners’ ability to solve problems and reinforce abstract concepts. It is equally learner-centered and focuses on achieving mastery of Science through experimenting, observation, and inferencing. These are proven methods of facilitating learning of Science, considering that the subject requires a lot of practicals and self-learning to internalize as opposed to memorization associated with the traditional learning methods.

The Objective of the Study

The objective of the study was to investigate the effects of Computer Assisted Learning on the learners’ mastery of Science concepts in selected universities in western Kenya.

Research hypothesis
H₀₁: There is no significant difference in learners' mastery of concepts in Science between students taught using CAL and those taught using traditional methods.

**METHODOLOGY**

**Research Design**

The study adopted the Solomon Four Group Design (Solomon, 1949) whereby the eight universities selected for the study were divided into two forming experimental and control groups. The target population comprised of 8 universities in western Kenya with a population of 2460 first-year students enrolled in science-based programs. The sample size of 335 first-year students was determined by use of Knejcie & Morgan table (1970), who were then randomly selected based on the subject combination of biology and physics. First-year students were selected for the study because of the change of teaching approach and broadness of the subject content in universities as compared to secondary education.

The research design involved (i) Pre-testing one experimental and one control group; (ii) administration of treatment to two experimental groups; and (iii) administration of post-test to all groups. The study was carried out in 4 months spanning 16 weeks where pretest was administered after the first eight weeks of conventional teaching and post-test administered after the next eight weeks of treatment. Pre-test and post-test Science Achievements Test (SAT) on two topics, digestive system and light and optics were designed and administered by the respective lecturers, and scores were recorded. Trained computer laboratory technicians were used to assist lecturers in teaching using CAL.

The pre-test was done to enable the researcher to check the entry behaviour and to determine whether the groups were similar in character before being taught using Computer Assisted Learning.

**Data analysis**

The data were analyzed using both descriptive and inferential statistics. Descriptive statistics (mean, standard deviation, and percentages) were used to summarize the data. Inferential statistics involved the use of ANOVA to analyze differences in the means of the post-test scores to find out whether there was any significant difference. t-test was conducted to determine whether a significant difference was present between the pre-tests and the post-tests of the group.

**RESULTS**

The pre-test scores for the learners are as shown in Table 1 below.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Control group 1 (C1)</th>
<th>Experimental group 1 (E1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>89</td>
<td>84</td>
</tr>
<tr>
<td>Mean</td>
<td>13.51</td>
<td>12.67</td>
</tr>
<tr>
<td>Standard Dev.</td>
<td>4.33</td>
<td>4.35</td>
</tr>
</tbody>
</table>

The results in table 1 above show that at the point of entry C1 and E1 had mean scores of C1=13.5 and E1=12.67 and standard deviation of 4.33 and 4.35, respectively, which is an indication of homogeneity of entry behaviour.

To determine the relative effect of CAL on learners’ achievement in mastery of Science concepts analysis of the learners’ pre-test and post-test SAT scores were carried out, as shown in Table 2 below.
After the study, Experimental group E1 had a higher (M=16.78, SD=3.68) mean score than that of (M=14.11, SD=2.57) the control group. The mean gain of E1 was also greater (M=4.15) than that (M=0.59) of C1. It was, therefore, necessary to perform a t-test analysis as shown in table 3 below since the mean results could not show whether the difference in mean gain between C1 and E1 were significant at the 0.05 level.

| table 3: Comparison of mean gain of groups on SAT |
|-----------------------------------|--------|-------------------|
| Df              | t-value | p-value |
| 75              | 2.851    | 0.006             |

The results in table 3 revealed that the difference in mean gain was significant at 0.05 level in favour of E1. This meant that the result of the mean gain analysis suggests that SAT enhances learners' achievement in the mastery of Science concepts.

The mean of the experimental groups E1 and E2 were generally higher than those of the control groups C1 and C2, as shown in table 4. This showed that CAL had an effect on improving achievement as compared with conventional methods.

| table 4: SAT Post Test mean and standard deviation |
|-----------------------------------|--------|-------------------|
| Group          | N  | Mean   | Standard deviation |
| C1             | 89  | 14.11  | 2.57               |
| C2             | 87  | 14.95  | 2.42               |
| E1             | 84  | 16.68  | 2.68               |
| E2             | 75  | 17.42  | 2.41               |
In order to find out whether the differences were significant at 0.05 level, an ANOVA was performed, and results presented in table 5.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>f-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>237.506</td>
<td>3</td>
<td>79.169</td>
<td>9.695</td>
<td>0.0000x</td>
</tr>
<tr>
<td>Within groups</td>
<td>1257.538</td>
<td>154</td>
<td>8.166</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>1495.044</td>
<td>157</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results in table 5 revealed that the difference in SAT mean scores among C1, C2, E1, and E2 was significant at the 0.05 level. The results, however, did not reveal where the differences were. Accordingly, a multiple comparison test (post Hoc) was performed to reveal where the differences were, as shown in table 6.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 v/s C2</td>
<td>-0.55</td>
<td>0.863</td>
</tr>
<tr>
<td>C1 v/s E1</td>
<td>-2.28</td>
<td>0.007</td>
</tr>
<tr>
<td>C1 v/s E2</td>
<td>-3.30</td>
<td>0.000</td>
</tr>
<tr>
<td>C2 v/s E1</td>
<td>-1.73</td>
<td>0.067</td>
</tr>
<tr>
<td>C2 v/s E2</td>
<td>-2.47</td>
<td>0.003</td>
</tr>
<tr>
<td>E1 v/s E2</td>
<td>-0.75</td>
<td>0.723</td>
</tr>
</tbody>
</table>

- C1 v/s E1 is significant in favour of E1
- C1 v/s E2 is significant in favour of E2
- C2 v/s E2 is significant in favour of E2

The result of the post hoc comparison analysis showed significant differences in favour of the experimental groups in that the subjects in the experimental groups outperformed the subjects that were in the control groups. It can, therefore, be concluded that the use of CAL seems to have led to relatively higher achievement than the use of traditional methods to teach the two areas of biology.

**DISCUSSION**

The study had sought to find out the effect of CAL on mastery of concepts in Science’s topics of digestive system and light and optics. The results show that students taught using CAL achieved significantly higher scores in SAT compared to those taught through the conventional method. This could be attributed to the fact that CAL provided students with a multisensory approach to learning since the computer simulations and animations gave reality to abstract concepts through 3D presentations, which were easy to manipulate and observe compared to the traditional approach. The students could
also learn at their own pace and review the concepts repeatedly without the computer becoming impatient or judgemental whenever a learner makes mistakes.

In the traditional method, the lecturer tends to dominate the class whereas in CAL neither the lecturer nor the learner dominates the process. CAL enhanced active manipulation of content and promoted interaction with content, and gave reality to abstraction. During CAL the lecturer’s role remained as a guide, and this allowed learning to be learner centered by enabling learners to explore and sharpen their problem-solving skills, which could be key in the mastery of concepts in Science. CAL also facilitated learners to be able to observe and make repeated inferences to concepts, thus mastering them. These findings were in agreement with similar studies carried by Bayrak & Bayram (2010); Tareef (2014); Sharma, (2017); Bryson & Hand, (2007); Jang, (2008); Troisi, (2014).

The mean gain in performance could be attributed to the fact that CAL made the learners be practically oriented, which agrees with a study by Millar (2004) and Abrahams & Reiss, (2012), which concluded that practical skills enhance learners grasp of Science concepts and knowledge about Science. The experimental groups outperformed the control groups since they were able to master the selected process skills like experimenting, observation, and inferences better than the control groups. This finding is consistent with other studies that suggested that the application of technology improves thinking skills and the use of meta-cognitive abilities as well as the acquisition of content knowledge in Science education (Carmichael & Farrell, 2012; Hopson, Simms & Knezeck, 2001).

CONCLUSIONS

Poor performance in science subjects has been attributed to the lose of critical manpower required to spur the economic growth and development of Kenya. However, as per the findings of this study, the introduction of CAL led to significant learning gains obtained by the learners exposed to treatment as compared to those not exposed to the treatment. Therefore, the use of CAL enhanced the acquisition of Science content, mastery of Science process skills that enable learners to understand the content deeper and equips them with knowledge for the future.

RECOMMENDATIONS

Based on the results, the study recommends the following: (i) a larger study to be carried out for generalization of results; (ii) Universities should incorporate the use of CAL in teaching and learning Science more so in topics involving experiments, making observation and inferences; (iii) universities curriculum developers should integrate CAL in the curriculum; and (iv) provide computers and computer training for teachers of Science to enhance the learning of science from universities.

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