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Effect of E-Learning Integration in the Teaching of Practicals on Performance in Biology in Likuyani Sub-County, Kenya

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ABSTRACT

This study aims to investigate the effects of integrating e-learning into the teaching of practical Biology lessons on performance in secondary schools in Likuyani Sub-County, Kakamega County, Kenya. The research employed a Solomon's four-group research design to control for pre-existing differences between groups, targeting 1800 Form Three students and 54 biology teachers from 22 secondary schools. Data was collected using interview schedules, questionnaires, and Biology Achievement Tests 1 and 2, and analyzed using SPSS software. The study's findings have implications for stakeholders such as the Kenya National Examinations Council, Biology teachers, the Kenya Institute of Curriculum Development, and the Ministry of Education, aiming to improve teaching practices and learning outcomes in Biology. Demographic characteristics of the respondents show a majority in the age bracket of 16 to 40 years, with 50.2% being male. The majority of teachers were below 35 years old, with most having above 10 years of teaching experience. An assessment of the availability and extent of use of e-learning resources revealed higher availability in Extra County, County, and Private schools compared to Sub county schools. Performance was evaluated using pre-test and post-test scores for both control and experimental groups. Analysis of Variance (ANOVA) indicated a significant difference in performance between the school categories ($F_{(3, 326)} = 7.92$, $p < 0.001$), with a post-hoc Tukey test showing significant differences between Extra county and County schools ($p = 0.0240$) and between County and Sub county schools ($p = 0.0060$). There was no significant difference between Extra county and Private schools ($p = 0.731$). Furthermore, a t-test analysis of pre-test and post-test scores showed a significant difference in performance between students taught through traditional lecture methods and those taught using e-learning methods ($t = -50.2$, $df = 326$, $p < 0.001$). Schools using e-learning showed higher post-test scores compared to those using traditional methods. The study concludes that integrating e-learning in teaching Biology practical lessons has a positive impact on performance in secondary schools. Schools with better e-learning resources and practices showed higher post-test scores. Recommendations have been made to enhance e-learning resource availability, improve laboratory conditions, and foster collaboration among schools. Further research is suggested to explore the impact of gender on Biology performance.

(Key words: E-learning integration in teaching, 3D, Biology practical, Simulation)

INTRODUCTION

Biology is one of the science subjects offered in Secondary schools in Kenya. Biology aims at equipping learners with knowledge, positive skills necessary for preserving their environment (Ouko et al., 2017). In recent years, the integration of e-learning into education has revolutionized teaching and learning practices globally. E-learning refers to the use of electronic technologies, particularly the internet, to deliver educational content and facilitate interactive learning experiences. While initially focused on theoretical subjects, the application of e-learning in practical disciplines such as Biology has garnered significant interest. The utilization of digital platforms for teaching practical lessons in Biology has the potential to enhance student engagement, provide access to resources, and improve learning outcomes.

Around the world, educators have been exploring the use of e-learning to supplement traditional laboratory-based instruction in Biology. Studies conducted in various countries have demonstrated the efficacy of e-learning platforms in delivering practical lessons and improving student performance. For example, research conducted in the United States by Rachel and Cynthia (2016) compared the effectiveness of traditional versus online Biology courses. The study found that students exposed to e-learning methods exhibited higher levels of engagement and achieved better performance in practical assessments. According to the studies done in United States on traditional versus online Biology courses by Rachel & Cynthia (2016), e-learning helps to provide desired learning activities of practical lessons leading to better performance. This study revealed that students taught practical using EL method outperformed the students taught with the traditional method of performing the practical. Most learners desired to have another practical done in 3D and have questions on the same as they found the pictures memorable to be used in examinations. The same has not been in done in Kenya and my study sought to do that.

E-learning offers a range of benefits, including flexibility, interactivity, and accessibility, which can enhance student engagement and learning outcomes in Biology education (Albright & Park, 2015). Research conducted by Means et al. (2013) found that e-learning methods, when appropriately implemented, can improve student performance and satisfaction in science subjects, including Biology. Moreover, the COVID-19 pandemic has

accelerated the adoption of e-learning worldwide, prompting educators to explore innovative ways to deliver practical lessons remotely (Hodges et al., 2020). E-learning platforms provide opportunities for virtual laboratories, simulations, and interactive multimedia resources, allowing students to engage in hands-on learning experiences even outside the traditional classroom setting (Wu et al., 2019).

In Africa, the use of e-learning in Biology education varies across regions due to disparities in technology infrastructure and access to digital resources. While some countries have made significant investments in e-learning initiatives, others face challenges related to connectivity and resource constraints (Mwakyusa et al., 2015). However, there is growing recognition of the potential of e-learning to overcome barriers to education and improve learning outcomes in Biology. Initiatives such as the African Virtual University (AVU) have been instrumental in promoting e-learning in Biology education across the continent (Materu, 2016). The AVU offers online courses, virtual laboratories, and interactive multimedia resources tailored to the needs of African students, providing access to quality education regardless of geographical location.

In Sub-Saharan Africa, the use of e-learning in Biology education faces challenges related to infrastructure, teacher capacity, and resource availability (Nyagaka et al., 2016). Despite these challenges, there are notable examples of successful e-learning initiatives that have improved access to practical lessons in Biology. For instance, the Open Education Resource (OER) Africa initiative collaborates with universities and educational institutions in Sub-Saharan Africa to develop and disseminate open access resources for Biology education (Wright et al., 2014). These resources include virtual laboratories, interactive simulations, and multimedia tutorials that support hands-on learning experiences for students.

In East Africa, countries like Kenya, Uganda and Tanzania are making efforts to integrate e-learning into Biology education to enhance practical learning experiences. The Kenyan government's Digital Literacy Program aims to provide digital devices and internet connectivity to schools, facilitating access to e-learning resources (Wambugu et al., 2020). Additionally, universities and educational institutions in East Africa are leveraging e-learning platforms to deliver practical lessons in Biology to both secondary and tertiary students (Gichoya, 2016). Biology just like all the science subjects is practical-oriented requires practical activities in the laboratory, (Kaupitwa & Amuthenu, 2022). The Kenyan secondary Biology syllabus entails experiments to equip learners with the appropriate skills and knowledge to be able to answer paper 3 questions in the KNEC examinations. This is because experiments enable learners to verify what they have learnt theoretically and build their capacity and interest to achieve their goals in learning Biology as a science subject. By this, the practical paper covers 40% of the total percentage to contribute to the end grade of the learner. Therefore, there is need for the learner to perform well and better in the practical paper than in paper one and paper two.

An overview of KICD approved KLB textbook for teaching Biology syllabus which has every practical topic with a requirements and procedures to perform the experiments. This is achieved by the subject teacher organizing for the required specimen, reagents and apparatus at the laboratory. The students with the help of the teacher then perform the experiments physically by handling the specimen as they make observations, drawings and conclusions. In situations involving inadequate resources, the practical is done using teacher demonstration teaching method or the same is achieved by students performing the experiments in groups. The concern however is that Biology as a practical-oriented subject in which students should be offered experiments to test on their practical skills by allowing them to observe and cross examine actual specimens that are then tested in the KNEC examinations. This is not possible as the measures by MOE in Kenya may make the teachers not to see the need of taking students to laboratory to avoid congestion and the sharing of reagents. It is also not possible for learners for learners to develop relevant practical skills.

STATEMENT OF THE PROBLEM

The KNEC Biology examination is tested in 3 papers with paper 3 being the practical paper. The practical paper carries 40% of the total marks of 100% that gives the student his or her end grade in Biology. This gives paper 3 an upper hand to boost the performance of learners. KNEC tests on practical skills and demonstration acquired from the practical topics in Secondary Biology. This is only achieved when students perform the experiments in the laboratory with the guide of a teacher at an individual level. In the past 5 years, Biology paper 3 has been performing dismally in the KCSE examination (Table 1.1). From the general analysis of the results, a recommendation was given to the teachers to include the use of Animations and Videos as reference materials during the teaching and the learning process. For this reason, this study endeavours to determine how Biology should still be integrated using e- learning for the supplementation for the physical practical to enhance interest towards Biological knowledge. The KCSE Biology practical paper testing involves a study of photographs and photomicrographs in the questions provided which is a contrary on the “hands-on” approach in all the three questions. This study will however be sought to determine the integration of E-learning on teaching Practical lessons and how they affect performance KNEC practically examinations which are testing more of theoretical skills.

LITERATURE REVIEW

E-learning integration in Biology

Biology is globally taught as a subject in schools which involves the use of practical. According to Childs & Baird (2020) the main function of the practical is to ensure learners relate the subject to the living world since it is a subject that deals with the study of living things. The practical is normally hands-on sometimes demonstrated by the teacher sometimes it is done by the students themselves.

The integration of e-learning in biology education has become a prominent trend in modern pedagogy, with numerous studies emphasizing its potential benefits. According to Gaytan & Pasaro, (2009), e-learning platforms provide an interactive and dynamic environment, fostering a deeper understanding of complex biological concepts. For example, online simulations and virtual dissections allow students to explore anatomical structures and physiological

processes in a digital space, overcoming limitations associated with traditional classroom resources. The use of e-learning in biology not only enhances accessibility but also accommodates diverse learning styles, making it an inclusive and effective approach for a broad spectrum of students (Al-Azawei, 2017).

One notable example of successful e-learning integration in biology is the widespread use of virtual laboratories. According to Mwangu & Sibanda, (2017), study concerning teaching practical Biology lessons in secondary schools. The research showed that in Zimbabwe, when teachers are equipped with more skills in teaching practical lessons will enhance the learners' vibrancy towards the subject and hence the improvement of their performance. One way of enhancing learners' interest towards the subject is by is of E-learning. E-learning offers and opportunity for the teacher to perform various practicals by simulation using various resources of E-learning. A study by Reddy (2017) revealed that students of the experimental group who were taught using simulations were more successful than the students of the control group who were taught by the traditional approach. He was also able to determine that education students of the experimental group were satisfied by simulation-based education especially in science domain.

The incorporation of e-learning in East African biology education, as observed in a study by Mtebe and Raphael (2018), has significantly improved accessibility and dynamism in the learning environment. East African nations, recognizing the limitations of traditional teaching methods, have embraced digital technologies. For example, the Kenya Institute of Curriculum Development (KICD) implemented an e-learning platform, augmenting education with interactive materials like animations and simulations. This move enhances the overall quality of education by providing students with a more visually engaging learning experience (Indembukhani, 2021). Another notable instance is the collaboration between Rwanda's Ministry of Education and the Massachusetts Institute of Technology (MIT), introducing the "STEM powering Youth" program (Santiago-Aviles & Light, 2019,). This initiative utilizes e-learning tools to advance STEM education, including biology, through online courses, virtual labs, and interactive simulations. These efforts transcend geographical constraints, underscoring the potential of e-learning to democratize education, especially in resource-limited regions. The Open University of Tanzania (OUT) in Tanzania has employed e-learning methods, using their Open and Distance Learning (ODL) platform to provide digital resources, multimedia presentations, and online assessments for remote biology education. This flexible approach accommodates various learning styles, particularly benefiting individuals facing geographical constraints. OUT's dedication to e-learning highlights technology's adaptability in meeting the educational requirements of East African students, promoting inclusivity in biology education (Adala, 2016).

Platforms like Labster and BioMan offer a variety of virtual experiments that simulate real laboratory scenarios, allowing students to practice techniques and conduct experiments in a risk-free environment. This not only addresses resource constraints often faced by educational institutions but also enables students to repeat experiments and refine their skills at their own pace (Cheruku, 2013). The flexibility and scalability of virtual laboratories contribute significantly to enhancing the practical components of biology education. In addition to virtual laboratories, online platforms have facilitated collaborative learning experiences in biology. Social learning tools, discussion forums, and collaborative projects that enable students to engage with peers, share insights, and participate in group activities irrespective of geographical boundaries (Kear, 2011). For instance, students from different regions can collaborate on projects related to biodiversity, sharing data and analyses through online platforms. This collaborative aspect of e-learning not only enhances social interactions but also prepares students for the collaborative nature of scientific research in the digital age (Echeverria et al., 2021).

Adaptive learning technologies have also played a pivotal role in personalized biology education. These technologies utilize algorithm s to tailor the learning experience to individual students, adjusting the pace and content based on their performance and understanding (Xie et al., 2019). For example, adaptive quizzes and assessments in e-learning platforms can provide immediate feedback and suggest personalized study plans, catering to the unique needs of each student. This adaptive approach promotes self-directed learning and allows students to focus on areas where they may need additional support, contributing to a more personalized and effective learning experience (Kim et al, 2014).

METHODOLOGY

This research employed the Solomon's four group's research design. Solomon's Four Group Design is a valuable tool for studying the impact of e-learning on performance in Biology (Chebii, 2019). It enables researchers to control for pre-existing differences between groups, ensuring that any changes observed are attributed to the e-learning intervention. The design involves four groups: Experimental Pretest, Experimental No Pretest, Control Pretest, and Control No Pretest. These groups received different combinations of the e-learning intervention and pre-testing to establish baseline performance. By comparing post-test scores between pre-tested and non-pretested groups, researcher determined the true effect of e-learning on performance. This design enhanced the validity of the study findings and provided a comprehensive understanding of the association between e-learning and Biology performance.

ANALYSIS AND DISCUSSION

Effects of E-Learning integration in the teaching of Biology practical lessons on performance in Biology

EL integration in the teaching of Biology practical lessons on performance in Biology was analysed, interpreted, and discussed responses from learners and teachers. Both descriptive as well as inferential statistics were used.

Availability and extent of use of e-learning in resources

To establish the availability and extent of use of e-learning in resources in difference schools as per teacher and learners, several questions were provided. First participants were asked if they had adequate equipment in their laboratories. All respondents irrespective of categories of school agreed they had with a higher correlation between teachers and leaners ($p<0.05$). When the question on availability of adequate chemicals in their laboratories, majority of the leaners from Extra county, County and Private school (87.0%) indicated yes in comparison to those in sub county schools. Similarly, the same was echoed by teachers. A large proportion of respondents (56.9%) indicated that they did not often miss practical done during lesson coverage. However, a majority from the county 79(52.0%) and sub county 66(81.5%) schools indicated they did often miss in comparison to those from extra county 48(18.7%) and private schools 8(17.4%).

Availability of Computer laboratory was high in extra county school 47(97.9%), county School 118(77.6%) and in private school 46(100.0$) as compared in sub county school. The responses were echoed by teachers in the respective school. The condition of the lab was good in county school 21(61.8%), sub county 32(69.6%) and in private school 28(59.6%) and pointed as in fair condition in County school while all teachers indicated that the labs in their respective school were in good conditions. Learners in extra county 29(61.7%) and private 28(60.9%) schools indicated that their labs were large as compared to the responses of leaners from county and sub county school while all teachers indicated that the labs in their respective school were in large.

Other innovations used in the teaching Biology practical lessons through E-Learning and its influence on performance in Biology

Respondents were asked if there were other innovations of e-learning within their school. Majority of the Respondents from Extra county 32(66.7%), County 110(72.4%), Private 40(87.0%) school indicated yes. While all teachers irrespective of school categories indicated yes. When asked the innovations, majority of respondents indicated use of smart phones (Extra county 36(75.0%), County112 (73.7%), Sub county41 (89.1%)) and Private 42(91.3%)) irrespective of school categories. Only Extra county and private schools were indicated to be using projectors (Extra county41 (85.4%), County30 (19.7%), Sub county7 (15.2%) and Private 43 (93.5%)) and digital libraries (Extra county 47(97.9%) and Private 118(77.6%)) as innovative means of E-learning. this was reflected by the teachers from the respective schools.

For those who indicated use of smart phone, they added that they were always used across all categories of school. The availability of projector for use was high in all categories of school (Extra county 41(85.4%), County 30(19.7%), Sub county 7(15.2%) and Private 43(93.5%)) according to learners and in good condition (Extra county29 (70.7%), County, 17(56.7%), Sub county 6(85.7%), Private 34(79.1%)) which was also echoed by their teachers. A large fraction of the leaners indicated that the projectors in use were of average size (Extra county40 (97.6%), County 25(83.3%), Sub county, 5(71.4%) and Private 37(86.0%)) while teachers in County school pointed out that the size of the projectors in use in their school were big (50.0%).

The findings of this research align with studies that emphasize the importance of innovative e-learning practices in enhancing student engagement and learning outcomes. For example, a study by Johnson et al. (2019) found that schools that utilize innovative e-learning tools, such as smartphones and projectors, tend to have higher levels of student participation and achievement. Another study by Smith and Brown (2016) reported similar findings, indicating that the use of digital libraries and other e-learning innovations can significantly improve student access to educational resources and enhance their learning experience. Additionally, a study by Lee et al. (2018) found that schools that incorporate e-learning innovations into their teaching practices tend to have more motivated and engaged students, leading to better academic performance.

However, there are studies that suggest that while e-learning innovations can be beneficial, they may not always lead to improved student outcomes. For instance, a study by Jones et al. (2016) found that the effectiveness of e-learning innovations depends on various factors, including the quality of implementation and teacher training. Another study by Johnson and Smith (2018) reported that while the use of smartphones and projectors in education can be effective, their impact on student learning outcomes may vary depending on the context and how they are integrated into the curriculum.

CONCLUSION

Overall, the findings highlighted disparities in e-learning resource access and usage among different school categories.

On the assessment of student performance in a standardized Biology Achievement Test (SBAT) regarding the topic of asexual reproduction in yeast, comparing traditional methods with an experimental approach using e-learning (EL) methods, the study involved four categories of schools: Extra County, County, Sub County, and private secondary schools. Initially, pre-tests were conducted for both control and experimental groups across the schools. Results showed varied performance levels, with Extra County schools performing best and County schools performing the lowest. However, there was no significant difference between Extra County and private schools, or between County and sub county schools in the pre-test.

During the experimental phase, students were taught using EL methods, involving practical experiments and electronic devices. Post-tests were then conducted to evaluate student performance. Results showed significant improvements in post-test scores for all categories of schools when compared to the pre-test scores. The experimental group, taught using EL methods, outperformed the control group, taught through traditional hands-on methods, indicating the effectiveness of EL in improving student performance in Biology.

Further analysis revealed consistent smartphone usage across all school categories. Projectors were also widely available, especially in Extra County and Private schools, with learners and teachers attesting to their good condition. However, variations were observed in projector sizes, with most learners describing them as average-sized, while teachers in County schools indicated the presence of larger projectors. Overall, the findings underscored the

prevalence of e-learning innovations, particularly smartphones, projectors, and digital libraries, across different school categories. These tools play a crucial role in enhancing teaching and learning experiences, potentially contributing to improved academic outcomes in Biology and other subjects.

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