Leveraging on Virtual Laboratory-Based Instruction to Achieve Active Classroom Interaction in Teaching and Learning of Physics in Secondary Schools in Kenya

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ABSTRACT

The philosophy that advances the study of physics as one of the learning areas in secondary schools cannot be overlooked due to the realization of the contributions of physics towards the industrial and vocational development of the country. The major concern of this particular study is the consistent poor average scores in the subject currently witnessed at the Kenya Certificate of Secondary Education (KCSE) level in Physics, which can be attributed to low student motivation and traditional teaching strategies. For instance, in the years 2016, 2017, 2018, and 2019, Kisumu County registered low mean scores of 4.23, 4.98, 4.67, and 4.10, respectively, in physics in KCSE. The use of Information and Communications Technology (ICT) in the teaching and learning of physics can be used to promote learners' centered teaching and learning of physics and eventually improve physics scores. This study therefore underscores the need for virtual laboratory-based instruction (VLBI) to realize active classroom interaction during the teaching and learning of physics. Technology-based enhanced learning leverages all learners, irrespective of their economic and demographic background. The study therefore aimed at establishing the effect of VLBI on students' level of interaction in the classroom in learning physics in secondary schools in Kenya. The study is supported by behaviorism learning theory and adopted quasi-experimental research designs. The physics teachers were purposefully sampled from each selected school. Physics teachers were purposefully sampled from each of the schools selected. There were 358 students and 72 teachers in the sample. The data was analyzed using both descriptive and inferential statistics. The study concluded that virtual laboratories enhanced the use of experimental teaching approaches and that there was no statistical significance between the knowledge of the teacher about the selected ICT framework and the use of virtual experiments. There is a need to develop a prototype for a technology-enriched ICT framework for active learning of physics that will provide teachers and students with an interactive platform to promote active physics learning.

Keywords: Virtual Laboratory (VL), ICT integration in learning, Active learning, Experiments

I. INTRODUCTION

Liu et al. (2017) consider Physics as the foundation of technology and science in view of the fact that most tools that are necessary for scientific and technological advancement are products of Physics, for instance, robotics and artificial intelligence. With regard to science and technology, Physics is considered an essential subject due to the fact that it covers the essence of natural occurrences and aids in understanding the rapid changes in technological trends (Wu, 2017). According to the Kenya Institute of Education, 2002, physics provides learners with the comprehension, skills and necessary knowledge for scientific research. It also encourages economic and technological growth in the society in which they live, which raises living standards (Minishi et al., 2005). That being the case, Physics education should not only be a course taught in secondary school stages but should be a lifelong and reiterative area of knowledge. The declining learners' motivation to study Physics and the lack of interest in the subject in secondary schools or rather avoiding Physics, has been a problem across several nations (Semela, 2010).The major concern of this study was the low average scores (4.495 between 2016 to 2019) in KCSE in Physics by students and the low enrolment data it has as a science as compared to Chemistry and Biology. All these concerns point at pedagogical approaches on the implementation of the Physics curriculum in secondary schools in Kenya. The study thus aimed at exploring the incorporation of VLBI in teaching and learning of Physics to improve learners' examination scores in secondary schools. This study investigated effects of VLBI on students' level of interaction in classroom in learning of Physics in secondary schools.

1.1 Study Objective

To establish the effect of VLBI on students' level of interaction in classroom in learning of Physics in secondary schools.

1.2 Research Hypothesis

The hypothesis tested in the study was that:

H_{01}: There is no statistically significant difference on students' level of interaction in class room interaction between students exposed to VLBI and those not exposed.

II. LITERATURE REVIEW

According to Conklin (2011), when ICT tools were combined with increased student engagement, higher-order thinking skills were improved. This is on the grounds that such a learning climate improves imagination than in an educator focused climate where educators are viewed as the main wellspring of information. According to Villers (2007), students are more likely to be creative when creativity is incorporated into instruction. The social constructivist approach to education is linked to collaborative learning and teamwork (Lam, 2015). According to Quintana et al. (2014)., effective integration of ICT enhances collaborative and active learning but also maintain that ICT-integrated learning encourages collaboration in the sense that it encourages communication, cooperation, and interaction as students collaborate with one another through group projects or teamwork during learning processes. Presently being developed technologies support learning through hands-on involvement, are interactive, and immediately provide feedback.

According to Stowell et al. (2010), the ability of ICT tools to provide immediate feedback and assess students' comprehension is an additional benefit that they bring to the learning environment. Similarly, ICT tools like VLBI can be used to check that learners understand fundamental concepts and help reinforce teaching and learning experiences (Papadopoulos et al, 2018). Stowell et al (2018) encourage teachers to regularly create virtual labs in order to observe student changes and enhance active learning. Smith et al (2020) also emphasizes the potential for VLBI to foster active and in-depth learning because it gives students the opportunity to discuss concepts in small groups. The respondents also confirmed that they were more attentive when ICT was integrated into the learning process and that they could inquire about additional information when certain ideas were unclear (Abdurrahman, 2018). Papadopoulos et al (2018) claim that, the development of VLBI enhances student learning and engagement. Kenya has yet to use virtual experiments, despite the benefits they offer and their impact on active learning (Beatty, 2016). The studies have, however, not shown the effect of integrating VLBI in the course of teaching and learning of Physics, whether the learners are involved in learning or are passive listeners. In addition, there is no experimental study that has explicitly established how ICT intervention through adoption of VLB in teaching of Physics in secondary schools can advance the learners' level of participation in classroom thus enhancing active learning. The current study therefore aimed at bridging this gap by establishing how VLBI alter learners' level of interaction in a classroom set up.

III. METHODOLOGY

This study employed Solomon's Four Quasi experimental research design. The Quasi-experimental design was found suitable for this study since the research participants (students) were not randomly assigned to experimental and control groups and the researcher worked with the existing intact classes. Once classes have been constituted in secondary schools, they are regarded as intact groups. The sample of this research was calculated by using Taro Yamane formula with 95% confidence level (Yamane, 1977). This formula confirmed a sample size of 358 students and 72 Physics teachers for the study. The sample consisted of Physics teachers who had undergone CEMESTEA in-service training on the use of Virtual Laboratory in teaching and learning of Physics and Form three Physics students. Kisumu County was purposively selected out of the 47 Counties in Kenya to be the county of study.
Therefore the sample size for each strata is given in Table 1

Table 1
Sampling Frame

Units	Population	Sample Size
Teachers	86	72
Students	3,500	358
Total	**3,586**	**430**

Source: Researcher (2018)

The data collection tools employed in this study entailed questionnaires, lesson observation guide and Physics Achievement Test. These tools were selected based on the following reasons; the nature of data to be collected, the time available for the study as well as the objectives of the study (Bergman, 2015). The overall aim of this study was to enhance active learning and to improve learning outcomes through integration of virtual experiments in teaching and learning of Physics in secondary schools in Kisumu County. The main concern of the study was on teachers' and students' views, opinions, and attitudes about ICT integration in active learning of Physics. This kind of information can best obtained through the use of questionnaires (Physics Teachers questionnaires and The Physics Student Questionnaire), and lesson observation (Kothari, 2017)

III.RESULTS

3.1 Comparison of Students Level of Interaction by Teaching Method

The aim of this study was to determine how VLBI affected students' level of classroom interaction during physics instruction in secondary schools. Data on this objective was analysed under the hypothesis: "There is no statistically significant difference on students' level of interaction in classroom between students exposed to VLBI and those not so exposed.'' In order to determine students' level of interaction in classroom when VLBI and conventional methods of teaching were used to teach Physics, data was collected on students' level of interaction using Physics Students Questionnaires, Physics Teaches Questionnaires and Lesson Observation Schedule. Table 2 shows the summary statistics of the results obtained.

Table 2
Independent t-test for Levels of Participation between the Two Groups

Methods of Teaching	N	Level of Participation	Std. Deviation	t-value	Df	Sig
VLBI	148	95.5688	11.4678	17.623	290	0.000
Conventional Method	144	62.7643	9.3465			

According to Table 2, students who were taught with VLBI were more engaged in the classroom (95.57) than students who were taught with conventional methods (62.76).The statistics also demonstrate that the difference in the two groups of students' mean levels of participation was statistically significant at $\alpha = 0.05$.The results of the study reveal that VLBI create an active learning environment in which small teams of students used computer based dynamics visualization and computer-based simulation as the key teaching aids providing foresight about the sophisticated dynamics exhibited by various radiations. VLBI enable students to control experimental inputs like voltage, light intensity, wavelength and they can in turn register immediate feedback on the variables being moderated.

Students can also create interactive half-life graphs, such as count rate versus time, current against time, and number of counts against time, using this simulation. Because they are able to see these graphs created in real time as they changed the controls on the experiment, students were able to see the relationship between the graphs and the experiment more clearly than they would when viewing static images. These findings are consistent with Manisha (2012) who contends that ICT can act as a catalyst by providing a learning platform which teachers use to improve teaching. Additionally, VLBI gives students access to electronic media that concretise concepts enhancing cognition.

3.2 Comparison of Level of Students Interaction across the Groups

To establish the level of students' interaction in the four groups involved in the study, a One Way ANOVA was carried out and the results presented in Table 3.

Table 3

ANOVA Table for Difference in Students Participation Level Across the Groups

	Sum of Squares	Df	Mean Squares	F	Sig
Between groups (treatment)	54121.568	3	18137.324	123.345	0.000
Within Groups (error)	21165.761	288	147.303		
Total	**62.7643**	**291**			

The results in Table 3 present an *F*-value of 123.345, whose significance level was 0.000. The results indicate that the difference in students' level of participation or classroom involvement among the four categories of students was statistically significant at an alpha level of 0.05. This implies that, the level of classroom interaction among the students varied significantly between the different groups.

To further determine how the variance in learners classroom interaction level is displayed, a post Hoc multiple comparison was done using the Duncan Multiple Range Test whose findings are presented in Table 4

Table 4

Duncan Multiple Range Test Statistics for Difference in Level of Students Participation Across the Groups

School	N	Subset for Alpha = .05			
		1	2	3	4
C_1	74	60.7649			
C_2	70		64.4210		
E_1	77			101.1100	
E2	71				96.5646
Sig.		**.001**	**.001**	**.001**	**.001**

The findings presented in Table 4 show that students in experimental class E_1 displayed highest level of participation (101.1) in the classroom during teaching and learning of Physics followed by students in experimental group E_2 (96.6) while students in C_1 were at 60.7. The high and improved level of students participation in the classroom depicted among the experimental classes can only be attributed to the use of VLBI in their classes since the classes were taken through the same topic (Radioactivity). The hypothesis which stated that "There is no statistically significant difference in students' level of interaction in classroom between students exposed to VLBI and those not exposed'' is thus rejected. The implication is that VLBI motivates learners to have interest in learning Physics.

The findings confirms the assertion of Holmes et al (2018) that established that, technological advancements increase students' active participation in class activities. The findings further corroborate previous studies (Abdurrahman et al, 2018; Smith et al, 2020; Stowell et al, 2018) which indicated that ICT integration promotes active learning. Furthermore, Desman et al (2017) noted that, there is substantial evidence that, use of experimental approach in learning and teaching improves students' activeness in Physics teaching learning process.

V.CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions

The study confirmed that, due to unique classroom environment, coupled with repetitive attributes of virtual labs, the Virtual Laboratory-Based Instruction in teaching and learning promoted students' level of classroom interaction and participation. This was witnessed by certain attributes, shown by the learners such as; hands on manipulation skills, interpretation skills and consequently their application of the learned subject matter in the real world situation.

5.2 Recommendations

Schools should be furnished with sufficient computer based teaching and learning resources since ICT integration promotes interactive learning, learners' interest and improves exams scores.

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